

MEMOIRS OF THE HOURGLASS CRUISES

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PART III

ECHINOIDS (ECHINODERMATA: ECHINOIDEA)

By

D. KEITH SERAFY¹

ABSTRACT

Twenty-five echinoid species including more than 44,000 specimens were collected during Project Hourglass, a 28-month survey of ten stations along two transects (depths 6-73 m) off the west Florida shelf. Differential diagnoses and information on distributions and substrate affinities are provided for all species; notes on diet, growth and reproduction, population dynamics, gear selectivity and morphometric and meristic relationships are provided for more common species. Keys to orders and 91 species and/or subspecies from the Gulf of Mexico or adjacent waters are provided; there is also a glossary of terms. Species and stations clustered into an inner shelf group at 6-18 m, a transitional group of stations at 37 m, and an outer shelf group at 55-73 m. The Gulf of Mexico has few endemic echinoid species; the fauna is composed primarily of species with tropical origins which have invaded the Gulf to varying degrees.

INTRODUCTION

Early exploration and sampling of the Gulf of Mexico has been discussed briefly by Galtsoff (1954). Until recently, the majority of benthic collecting in the Gulf was conducted by the research vessels *Blake*, *Albatross* and *Fish Hawk* between 1872 and 1915. Early work was restricted to the eastern portion of the Gulf and was concentrated off northwestern Cuba. Offshore benthic collecting was resumed in the 1950's when the R/V *Oregon*, and later several other vessels, began sampling in the Gulf.

¹Southampton College, Southampton, New York 11968.

This public document was promulgated at an annual cost of \$8202 or \$4.10 per copy to provide the scientific data necessary to preserve, manage, and protect Florida's marine resources and to increase public awareness of the detailed information needed to wisely govern our marine environment.

These early expeditions provided general information on faunal and floral compositions and on species distributions, both bathymetric and geographic. However, more detailed information on the ecology of marine species is necessary as man increases his demands on the sea and rapidly changes his environment. Data on population numbers and fluctuations, reproduction, growth and seasonal phenomena must be obtained before realistic management of our marine resources can be accomplished. The most effective method of obtaining these kinds of data on many species is by sampling fixed locations at specific time intervals with the same gear.

Echinoids comprise a large portion of the invertebrate benthos off western Florida. A. Agassiz (1878) reported 32 species of echinoids from the Gulf of Mexico. A. H. Clark (1954) published a checklist of 66 species from the Gulf, but many of these were not known from within the Gulf of Mexico proper, defined herein as the area enclosed by a line connecting the southern Florida Keys and Cabo Catoche, northeastern Yucatan. In certain instances specimens were known only from off northern Cuba or from some other adjacent area in the Caribbean. A. H. Clark apparently assumed that species found at the mouth of the Gulf would also occur further north in the more poorly sampled areas. Although this has sometimes proven true, only 54 of Clark's species are yet known from the Gulf of Mexico. However, additional species have been revealed from recent investigations.

In August 1965, the Florida Department of Natural Resources (FDNR) Marine Research Laboratory began systematic collections along two transects off the Florida west coast (Figure 1) with the 72-ft R/V *Hernan Cortez*, thus enabling seasonal quantitative and qualitative studies of echinoids at fixed locations. Over 44,000 echinoid specimens representing 25 species were collected. Keys to the orders and species known from the Gulf of Mexico and adjacent waters are provided along with information on the biology of Hourglass species. Localized distributions of Hourglass echinoids are discussed, as well as distributions of the entire Gulf echinoid fauna.

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METHODS AND MATERIALS

Complete sampling procedures and rationale, presented by Joyce and Williams (1969), are herein summarized. Benthic Stations A, B, C, D and E (6, 18, 37, 55 and 73 m depths) along the northern transect and Stations I, J, K, L and M at equivalent depths (Table 1) along the southern transect were sampled monthly at night from August 1965 through November 1967. Stations B, C and D were sampled a second time each month (Post HC cruises) during the day.



Figure 1. Hourglass cruise pattern and station locations.

TABLE 1. LOCATION AND DEPTH OF HOURGLASS STATIONS PRODUCING ECHINOIDEA.

Station	Latitude*	Longitude*	Established Depth (meters)	Approximate Nautical Miles Offshore*
A	27°35'N	82°50'W	6.1	4, due W of Egmont Key
B	27°37'N	83°07'W	18.3	19, due W of Egmont Key
C	27°37'N	83°28'W	36.6	38, due W of Egmont Key
D	27°37'N	83°58'W	54.9	65, due W of Egmont Key
E	27°37'N	84°13'W	73.2	78, due W of Egmont Key
I	26°24'N	82°06'W	6.1	4, due W of Sanibel Island Light
J	26°24'N	82°28'W	18.3	24, due W of Sanibel Island Light
K	26°24'N	82°58'W	36.6	51, due W of Sanibel Island Light
L	26°24'N	83°22'W	54.9	73, due W of Sanibel Island Light
M	26°24'N	83°43'W	73.2	92, due W of Sanibel Island Light

*U.S. Coast and Geodetic Chart No. 1003, dated June 1966.

Each station was sampled with a rectangular box dredge for 15 min and a trynet (small otter trawl) for 30 min at a speed of about two knots. The dredge, 91 cm wide, 33 cm high and 76 cm deep, was lined with 1.9 by 3.8 cm expanded metal mesh. The trynet was 6.1 m wide (door to door) with 5.1 cm stretched mesh. In July 1966 (Supplementary HC 29) and January 1967 (Supplementary HC 35), each station was fished for 30 min with a 13.8 m wide (door to door) balloon-type otter trawl pulled at about two knots, in addition to normal monthly collecting.

During December 1965 and March 1966, collecting along the southern transect was interrupted by bad weather, forcing the vessel to return to Ft. Myers before sampling was completed. Therefore, Station L (December) and Stations I, J and K (March) were repeated. In May 1966 the vessel encountered bad weather while returning to St. Petersburg and several sample containers broke open. Some specimens became mixed and these data are listed as questionable.

Stations A, B, C, I, J and K were examined with SCUBA in July and August 1967. Two-man teams dived at each station to make observations, photograph the bottom, take substrate samples and make limited collections.

Specimens were preserved in 10 per cent Formalin and later transferred to 70 per cent ethanol. Many specimens were then dried. Measurements were taken with calipers to the nearest 0.1 mm.

Morphological characters of echinoids are best seen on dried specimens. Household bleach was used to remove tissue and expose test sculpture. Plate sutures were observed by carefully removing spines with a small brush and applying xylene. When this was not sufficient, a fine file was used to remove the outer sculpturing of the test.

Pedicellarial preparations were made by placing a pedicellaria on a glass slide with a few drops of 50 per cent household bleach until the valves separated freely. For permanent slides, bleach was absorbed with a paper towel, then a few drops of water added. Rinsing was repeated at least twice and then the slide allowed to dry. A standard mounting medium (e.g., Permout) was then placed on the slide and a cover slip added.

Predictive linear regression of y on x was used in the meristic and morphometric sections. The basic assumption in this type of regression is that x is an independent and y a dependent variable. Teissier (1948), Sprent (1968) and Ricker (1973) point out that regression equations in biology often do not have a truly independent variable. It is true that in this study the independent variable (HD or TL) is not independent and the geometric functional regression discussed by Ricker (1973) would be more appropriate. However, by

using the predictive regression it is possible for the taxonomist to determine whether a given specimen is "species a" or "species b" by measuring TL or HD and some other taxonomically important character. Geometric function regression makes this more difficult.

Numerical classification (cluster analysis) was used to show the similarity of Hourglass stations using species as attributes (normal analysis) and the similarity of species using stations as attributes (inverse analysis). These normal and inverse classifications were obtained using the program COMPAH developed at the Virginia Institute of Marine Science. Species abundance was log transformed ($\log x + 1$), interentity resemblance was expressed by the Bray-Curtis similarity measure, and the sorting strategy was group average (Clifford and Stephenson, 1975).

Figure 2 is provided to help the reader use the glossary and keys. Some abbreviations for meristic and morphometric characters have been used earlier by Serafy (1971), but many are here introduced for the first time. Size ranges listed in material examined sections represent HD for all regular echinoids and TL for all irregular echinoids.

Selected specimens were deposited in the collection of the Florida Department of Natural Resources Marine Research Laboratory (FSBC I); remaining specimens were donated to the National Museum of Natural History, Smithsonian Institution (USNM), Washington, D.C., but many have not yet been accessioned into the collection.

GLOSSARY

ABORAL — side opposite mouth.

ADAPICAL — toward or near apical system.

ADORAL — toward or near mouth.

AMBITUS — greatest horizontal test circumference (Figure 2a).

AMBULACRUM — one of five segments of test, composed of two columns of plates (a and b, designated counterclockwise) extending from apical system to peristome, underlain by radial water vessel, and alternating with five interambulacral segments; designated by Roman numerals in Lovén's system.

ANTERIOR UNPAIRED PETAL — petal III of Lovén's system (Figure 2a).

APEX — highest part of test.

APICAL SYSTEM — plates at aboral terminus of ambulacra and interambulacra, including ocular and genital plates (Figure 2c).

AREOLE — scrobicule or depression around boss of tubercle for attachment of muscles controlling movement of spines.

ARISTOTLE'S LANTERN — structure of 40 or fewer skeletal elements serving for mastication.

BASICORONAL PLATE — plate adjacent to peristome.

BIGEMINATE — having two pore-pairs.

BOURRELET — externally inflated adoral part of interambulacral areas.

BUCCAL PLATE — large primordial plate on peristome, with pores for buccal tube feet.

COLLAR — smooth tapering portion of spine located above milled ring.

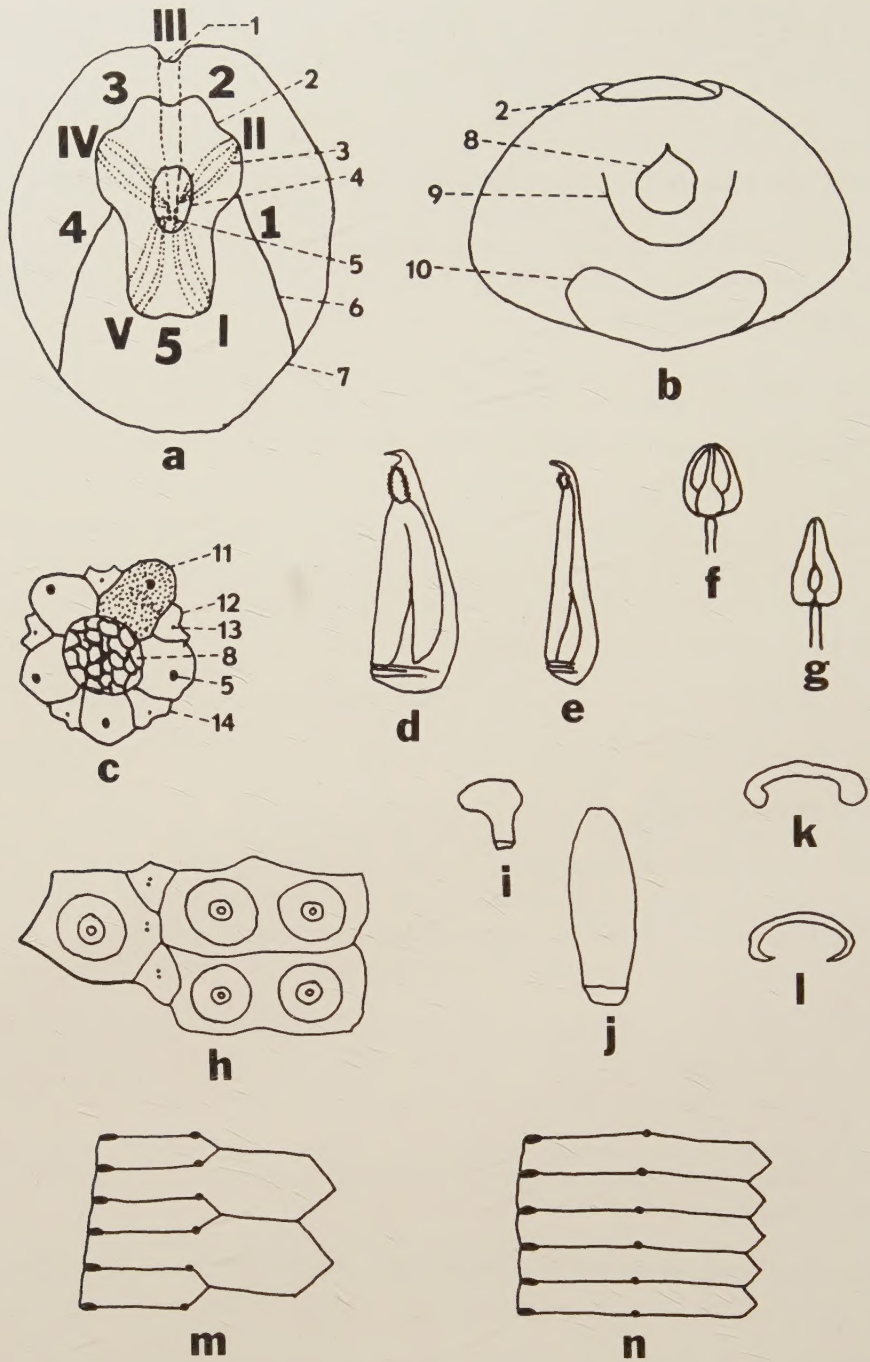


Figure 2. Echinoid morphological characters: a, aboral aspect of generalized spatangoid with Lovén's numbering system (see glossary) superimposed; b, posterior aspect of generalized spatangoid; c, apical system of regular echinoid; d, valve of globiferous pedicellaria with end tooth and large opening distally; e, valve of globiferous pedicellaria with end tooth and small opening distally; f, strongly involuted tridentate pedicellaria of *Araeosoma belli*; g, scarcely involuted tridentate pedicellaria of *Araeosoma fenestratum*; h, ambulacral and interambulacral plate arrangement on oral surface of *Phormosoma placenta*; i, periproctal spine of *Salenocidaris varispina*; j, periproctal spine of *Salenocidaris profundus*; k, dumbbell-shaped spicule of globiferous pedicellaria; l, C-shaped spicule of globiferous pedicellaria; m, pseudocompound ambulacral plates within petal; n, simple ambulacral plates within petal.

1, frontal notch; 2, peripetalous fasciole; 3, petal; 4, inner fasciole; 5, genital pore; 6, lateral fasciole; 7, ambitus; 8, periproct; 9, anal fasciole; 10, subanal fasciole; 11, madreporite (genital plate 2); 12, ocular plate II (exsert); 13, ocular pore; 14, ocular plate I (insert).

COMPOUND PLATE — ambulacral plate unit composed of two or more individual plates, each with pore-pair for tube foot, bound together by single large primary tubercle.

CRENULATE — descriptive term for tubercle with ribbed periphery.

EXSERT — ocular plates separated from periproctal margin by genital plates (Figure 2c).

FASCIOLE — narrow band of small, densely arranged, ciliated spines (clavulae) in which cilia beat to create currents; on denuded test, a narrow band of small tubercles which bear the spines (Figure 2a, b).

FRONTAL DEPRESSION OR NOTCH — indentation of ambulacrum III at ambitus (Figure 2a).

GENITAL PORE — opening in genital plate for discharge of reproductive products (Figure 2a, c).

GILL SLIT — indentation of peristomal margin of interambulacra for passage of stem of external branchia.

GLOBIFEROUS PEDICELLARIA — type of pedicellaria with three valves containing poison glands (Figure 2d, e).

IMPERFORATE TUBERCLE — tubercle without small depression on top.

INNER FASCIOLE — fasciole surrounding apical system and crossing all petals (Figure 2a).

INTERPORIFEROUS ZONE — area between two inner pore-rows of ambulacrum.

INSERT — ocular plates in contact with periproctal margin (Figure 2c).

INTERAMBULACRUM — one of five segments of test composed of two columns of plates (a and b, designated counterclockwise) extending from apical system to peristome and alternating with ambulacra; designated by Arabic numerals in Lovén's system.

INTERRADIAL SUTURE — suture between two columns of plates in interambulacrum.

LABRUM — more or less enlarged, modified, lip-like, primordial plate bordering peristome in interambulacrum 5.

LATEROANAL FASCIOLE — fasciole composed of lateral and anal fascioles which passes under periproct and connects anteriorly to peripetalous fasciole.

LOVÉN'S SYSTEM — numbering system in which ambulacral and interambulacral areas of test are designated by Roman (I-V) and Arabic (1-5) numerals respectively (Figure 2a).

LUNULE — opening through test of some sand dollars; used in feeding and burrowing.

MARGINAL FASCIOLE — fasciole extending around ambitus.

MILLED RING — flange near base of spine for attachment of muscles that move spine.

OCULAR PLATE — primordial plate of apical system at terminus of ambulacrum (Figure 2c).

OCULAR PORE — perforation in ocular plate for passage of terminal tentacle (Figure 2c).

ORAL — side of test on which mouth is located.

PAIRED PETALS — petals I and V, II and IV.

PERFORATE TUBERCLE — tubercle with small depression on top for ligament connecting spine and tubercle.

- PERIPETALOUS FASCIOLE** — fasciole passing around petals I, II, IV and V and around or across petal III (Figure 2a, b).
- PERIPROCT** — opening in test for anus, covered in life by periproctal membrane, commonly plated (Figure 2b, c).
- PERISTOME** — opening in test for mouth, covered in life by peristomal membrane, commonly plated.
- PERRADIAL** — having meridional position at mid-line of ambulacrum.
- PETAL** — differentiated adapical segment of ambulacrum with tube feet specialized for respiration; pores of a pore-pair are typically unequal and enlarged (Figure 2a).
- PHYLLODE** — area of enlarged pores in adoral portion of ambulacrum.
- PLASTRON** — more or less inflated, enlarged portion of interambulacrum 5, composed of one or two large plates posterior to labrum.
- POLYPOROUS PLATE** — compound or pseudocompound ambulacral plate with many pore-pairs, usually five or more.
- PORE-PAIR** — two ambulacral pores separated by wall of stereom through which single tube foot passes.
- PORE-SERIES** — series of pore-pairs; two pore series compose a petal.
- PRIMARY SPINE** — first-formed, usually largest, spine of test plates, situated over growth center of plate except on compound ambulacral plates.
- PRIMARY TUBERCLE** — large tubercle articulating with primary spine.
- PSEUDOCOMPOUND** — group of two or more associated primary or reduced plates not bound together by primary tubercle (Figure 2m).
- SCROBICULAR SPINE** — small flattened spines found around base of primary tubercle.
- SIMPLE AMBULACRAL PLATE** — ambulacral plate with only one pore-pair (Figure 2n).
- STEREOM** — calcareous mesh of which skeletal elements are composed.
- SUBANAL FASCIOLE** — fasciole enclosing a more or less elliptical area on posterior face of test below periproct (Figure 2b).
- SURANAL PLATE** — first-formed, largest plate of periproctal system.
- SUTURE** — narrow zone marking contact between adjacent plates.
- TRIDENTATE PEDICELLARIA** — pedicellaria with three long, pointed, jaw-like valves (Figure 2f, g).
- TRIGEMINATE** — having three pore-pairs on each ambulacral plate.

ABBREVIATIONS

- ABAM** — number of aboral ambulacral plates from distal portion of petal II or IV to ambitus.
- ABIA** — number of aboral interambulacral plates from apex to ambitus in interambulacrum 1b or 4a.
- AD** — maximum diameter of largest areole on an interambulacral plate.

AMB — number of ambulacral plates in column from apical system to peristome.

AS — diameter of apical system.

DMI — depth of marginal indentation at ambulacrum II or IV.

HD — horizontal test diameter.

IA — number of interambulacral plates in column from apical system to peristome (any column in a regular echinoid and column 1b or 4a in an irregular echinoid).

LUN — length of interambulacral lunule.

LUNAP — distance from apex to anterior portion of interambulacral lunule.

MIPW — maximum distance between inner pores of each pore-pair series in a plane perpendicular to perradial suture in petal II or IV.

OPAMB — number of ambulacral plates outside petal II or IV.

OPW — maximum distance between outer pores of both pore series in a plane perpendicular to axis of perradial suture in petals II or IV.

ORAM — number of oral ambulacral plates between peristome and ambitus in ambulacrum II or IV.

ORIA — number of oral interambulacral plates, excluding basicoronal plate, from mouth to ambitus in interambulacrum 1b or 4a.

PAMB — number of ambulacral plates in longest pore-pair series within petal II or IV.

PH — maximum periproct height.

PL — length of petal II or IV.

PP — maximum diameter of periproct.

PS — maximum diameter of peristome.

PSW — peristome width.

PW — periproct width.

SD — diameter of largest primary interambulacral spine just above collar.

SL — length of largest primary interambulacral spine.

TH — test height.

TL — test length.

TUB — number of primary tubercles in a column of interambulacral plates.

TW — test width.

SYSTEMATICS

Eighty-nine species and two subspecies of echinoids, contained in 13 orders and 25 families, are known from the Gulf of Mexico and adjacent waters (Table 2), defined for this study as waters along the eastern coast of the Yucatan Peninsula, northern coast of Cuba and northern Bahama Islands. Many of these data are new and were extracted from a study in progress on the zoogeography of North Atlantic echinoids by D. K. Serafy and F. J. Fell. Keys to all taxa are provided. The Hourglass collections contained 25 species, and one other has been obtained from the area in other FDNR collections.

TABLE 2. ECHINOIDEA FROM GULF OF MEXICO AND ADJACENT WATERS.

Species	Known Depth Range (m)
Order Cidaroida Claus, 1880	
Family Cidaridae Gray, 1825	
+ <i>Histocidaris nuttingi</i> Mortensen, 1926	225-740
+ <i>Histocidaris sharreri</i> (A. Agassiz, 1880)	200-740
+ <i>Porocidaris pupurata</i> (Wyville-Thomson, 1872)	620-2200
+ <i>Stereocidaris ingolfiana</i> Mortensen, 1903	300-1745
<i>Cidaris abyssicola</i> (A. Agassiz, 1869)	85-800
+ <i>Cidaris blakei</i> (A. Agassiz, 1878)	270-720
+ <i>Cidaris rugosa</i> (H. L. Clark, 1907)	150-790
+ <i>Calocidaris micans</i> (Mortensen, 1903)	170-600
* <i>Eucidaris tribuloides tribuloides</i> (Lamarck, 1816)	0-800
* <i>Stylocidaris affinis</i> (Philippi, 1845)	23-1000
+ <i>Stylocidaris lineata</i> Mortensen, 1910	70-560
+ <i>Tretocidaris bartletti</i> (A. Agassiz, 1880)	48-625
Order Echinothuroida Claus, 1880	
Family Echinothuridae Wyville-Thomson, 1872	
<i>Araeosoma belli</i> Mortensen, 1903	130-1020
<i>Araeosoma fenestratum</i> (Wyville-Thomson, 1872)	160-1180
<i>Hygrosoma petersii</i> (A. Agassiz, 1880)	200-3700
+ <i>Sperosoma antillense</i> Mortensen, 1934	720-880
<i>Phormosoma placenta placenta</i> Wyville-Thomson, 1872	50-3700
<i>Phormosoma placenta sigsbei</i> A. Agassiz, 1880	200-1800
Order Diadematoidea Duncan, 1889	
Family Diadematidae Gray, 1855	
* <i>Diadema antillarum</i> (Philippi, 1845)	0-400
* <i>Astropyga magnifica</i> A. H. Clark, 1934	11-88
* <i>Centrostephanus longispinus rubricingulus</i> H. L. Clark, 1921	33-310
Family Aspidodiadematidae Duncan, 1889	
+ <i>Aspidodiadema jacobyi</i> A. Agassiz, 1880	170-720
<i>Plesiodiadema antillarum</i> (A. Agassiz, 1880)	720-3000
Order Pedinoida Mortensen, 1939	
Family Pedinidae Pomel, 1883	
+ <i>Caenopedina cubensis</i> A. Agassiz, 1869	250-1200
Order Salenioida Delage and Herouard, 1903	
Family Saleniidae L. Agassiz, 1838	
<i>Salenia goesiana</i> Lovén, 1874	90-540
+ <i>Salenocidaris profundus</i> (Duncan, 1877)	220-3700
+ <i>Salenocidaris varispina</i> A. Agassiz, 1869	250-3000

TABLE 2. ECHINOIDEA FROM GULF OF MEXICO AND ADJACENT WATERS (Continued).

Species	Known Depth Range (m)
Order Arbacioida Gregory, 1900	
Family Arbaciidae Gray, 1855	
* <i>Arbacia punctulata</i> (Lamarck, 1816)	0-225
* <i>Coelopleurus floridanus</i> A. Agassiz, 1871	73-530
+ <i>Habrocidaris scutata</i> (A. Agassiz, 1880)	920-1400
<i>Podocidaris sculpta</i> A. Agassiz, 1869	230-730
Order Temnopleuroidea Mortensen, 1942	
Family Temnopleuridae A. Agassiz, 1872	
* <i>Genocidaris maculata</i> A. Agassiz, 1869	12-420
+ <i>Trigonocidaris albida</i> A. Agassiz, 1869	70-720
Family Toxopneustidae Troschel, 1872	
+ <i>Lytechinus callipeplus</i> H. L. Clark, 1912	22-350
* <i>Lytechinus euerces</i> H. L. Clark, 1912	55-777
* <i>Lytechinus variegatus carolinus</i> A. Agassiz, 1863	0-75
<i>Lytechinus variegatus variegatus</i> (Lamarck, 1816)	0-250
<i>Lytechinus williamsi</i> Chesher, 1968	5-92
<i>Tripeustes ventricosus</i> (Lamarck, 1816)	0-55
Order Echinoida Claus, 1876	
Family Echinidae Gray, 1825	
+ <i>Echinus gracilis</i> A. Agassiz, 1869	70-450
+ <i>Echinus tyloses</i> H. L. Clark, 1912	270-810
Family Echinometridae Gray, 1825	
<i>Echinometra lucunter</i> (Linné, 1758)	0-45
+ <i>Echinometra viridus</i> A. Agassiz, 1863	0-40
Order Holoctypoida Duncan, 1889	
Family Echinoneidae L. Agassiz and Desor, 1847	
<i>Echinoneus cyclostomus</i> Leske, 1758	5-570
Order Clypeasteroida A. Agassiz, 1872	
Family Clypeasteridae L. Agassiz, 1835	
* <i>Clypeaster chesheri</i> Serafy, 1970	20-101
+ <i>Clypeaster cyclopilus</i> H. L. Clark, 1941	70-460
+ <i>Clypeaster euclastus</i> H. L. Clark, 1941	36-530
+ <i>Clypeaster lamprus</i> H. L. Clark, 1914	78-450
* <i>Clypeaster prostratus</i> Ravenel, 1848	15-75
* <i>Clypeaster ravenelii</i> (A. Agassiz, 1869)	50-230
<i>Clypeaster rosaceus</i> (Linné, 1758)	0-285
* <i>Clypeaster subdepressus</i> (Gray, 1825)	5-210
Family Fibularidae Gray, 1855	
<i>Echinocyamus grandiporus</i> Mortensen, 1907	150-2500
+ <i>Echinocyamus macrostomus</i> Mortensen, 1907	170-2286
Family Mellitidae Stefanini, 1911	
* <i>Mellita quinquiesperforata</i> (Leske, 1778)	0-180
<i>Leodia sexiesperforata</i> (Leske, 1778)	0-60
* <i>Encope aberrans</i> Martens, 1867	12-90
* <i>Encope michelini</i> L. Agassiz, 1841	3-90
Order Cassiduloida Claus, 1880	
Family Echinolampadidae Gray, 1851	
* <i>Echinolampas depressa</i> Gray, 1851	37-310
<i>Conolampas sigsbei</i> (A. Agassiz, 1878)	130-800
Family Cassidulidae L. Agassiz and Desor, 1847	
+ <i>Cassidulus caribaeorum</i> Lamarck, 1801	57-197

TABLE 2. ECHINOIDEA FROM GULF OF MEXICO AND ADJACENT WATERS (Continued).

Species	Known Depth Range (m)
Family Neolampidae Lambert, 1918	
+ <i>Neolampas rostellata</i> A. Agassiz, 1869	145-1260
Order Holasteroida Durham and Melville, 1957	
Family Pourtalesiidae A. Agassiz, 1881	
<i>Pourtalesia miranda</i> A. Agassiz, 1869	450-5850
Order Spatangoida Claus, 1876	
Family Hemiasteridae H. L. Clark, 1917	
<i>Hemiaster expergitus</i> Lovén, 1874	380-4833
<i>Sarsiaster griegii</i> Mortensen, 1950	1900-3120
Family Schizasteridae Lambert, 1905	
* <i>Schizaster orbignyianus</i> A. Agassiz, 1880	26-500
<i>Hypselaster brachypetalous</i> H. L. Clark, 1917	750-1750
<i>Hypselaster limicolus</i> (A. Agassiz, 1878)	30-340
+ <i>Paraster dodderleini</i> Cheshier, 1972	12-220
+ <i>Paraster floridiensis</i> (Kier and Grant, 1965)	2-25
* <i>Agassizia excentrica</i> A. Agassiz, 1869	43-900
* <i>Moiria atropos</i> (Lamarck, 1816)	0-445
Family Aeropsidae Lambert, 1896	
<i>Aeste bellidifera</i> Wyville-Thomson, 1877	550-5220
Family Brissidae Gray, 1855	
<i>Brissus unicolor</i> (Leske, 1778)	0-240
<i>Brissopsis alta</i> Mortensen, 1907	45-310
* <i>Brissopsis atlantica</i> Mortensen, 1907	26-641
<i>Brissopsis elongata elongata</i> Mortensen, 1907	3-270
+ <i>Brissopsis mediterranea</i> Mortensen, 1913	37-3200
* <i>Meoma ventricosa ventricosa</i> (Lamarck, 1816)	2-200
+ <i>Plethotaenia angularis</i> Cheshier, 1968	150-623
<i>Plethotaenia spatangoides</i> (A. Agassiz, 1883)	150-619
* <i>Plagiobrissus grandis</i> (Gmelin, 1788)	1-210
+ <i>Rhinobrissus micrasteroides</i> A. Agassiz, 1878	148-330
Family Loveniidae Lambert, 1905	
* <i>Echinocardium laevigaster</i> A. Agassiz, 1869	40-220
<i>Araeolampas atlantica</i> Serafy, 1974	1920-3595
<i>Homolampas fragilis</i> (A. Agassiz, 1869)	360-3550
Family Asterozomatidae Pictet, 1857	
<i>Archaeopneustes hystrix</i> (A. Agassiz, 1880)	220-1610
+ <i>Linopneustes longispinus</i> (A. Agassiz, 1878)	55-710
<i>Palaeobrissus hilgardi</i> A. Agassiz, 1883	150-1025
<i>Paleopneustes cristatus</i> A. Agassiz, 1873	76-805
+ <i>Paleopneustes tholoformis</i> Cheshier, 1968	90-525

*Hourglass species.

+ Species occurring near the mouth of the Gulf of Mexico but not yet collected from within the Gulf proper.

KEY TO ORDERS OF ECHINOIDEA FROM THE GULF OF MEXICO AND ADJACENT WATERS

1. Periproct within apical system	2
1. Periproct outside apical system	9
2. Ambulacral plates with tube feet continuing over peristome in series of plates between mouth and edge of peristome	3
2. Ambulacral plates with tube feet not continuing over peristome in series of plates, only single pair of buccal plates present on peristome	4
3. Test rigid; interambulacral plates with only one large primary tubercle and spine	CIDAROIDA (p. 14)
3. Test flexible, with imbricating plates or interstitial membranous junctions; interambulacral plates with more than one primary tubercle and spine	ECHINOTHUROIDA (p. 23)
4. Tubercles perforate	5
4. Tubercles imperforate	6
5. Primary tubercles crenulate	DIADEMATOIDA (p. 23)
5. Primary tubercles non-crenulate	PEDINOIDA; <i>Caenopedina cubensis</i> A. Agassiz (p. 29)
6. Interambulacral plates as in cidaroids, with only one large tubercle and spine; scrobicular spines present; periproct displaced well off center	SALENIOIDA (p. 29)
6. Interambulacral plates with more than one primary tubercle and spine; no scrobicular spines present; periproct not displaced well off center	7
7. Periproct with four or five triangular valves composing anal pyramid	ARBACIOIDA (p. 30)
7. Periproct without four triangular valves fitted together in shape of pyramid	8
8. Ambulacral plates trigeminate; gill slits narrow, deep	TEMNOPLEUROIDA (p. 40)
8. Ambulacral plates polyporous; gill slits shallow	ECHINOIDA (p. 56)
9. Aristotle's lantern present in juveniles and adults	10
9. Aristotle's lantern never present, or only present in small juveniles	11
10. Ambulacral pores not forming petals; ambulacral areas much narrower than interambulacral areas on oral surface	HOLECTYPOIDA; <i>Echinoneus cyclostomus</i> Leske (p. 57)
10. Ambulacral pores forming distinct petals; ambulacral areas as wide as or wider than interambulacral areas on oral surface	CLYPEASTEROIDA (p. 57)
11. Phyllodes and bourrelets present; mouth central, without labrum; Aristotle's lantern present in very small juveniles, resorbed in larger juveniles and adults	CASSIDULOIDA (p. 82)
11. Phyllodes and bourrelets absent; mouth anteroventral, with labrum; Aristotle's lantern never present	12

12. Test bottle-shaped, very fragile; plastron widely separated from labrum; ambulacra I and V widely separated from apical system by interambulacra 1 and 4 HOLASTEROIDA; *Pourtalesia miranda* A. Agassiz (p. 85)
12. Test not bottle-shaped, either fragile or sturdy; plastron adjacent to labrum; ambulacra I and V attached to apical system SPATANGOIDA (p. 86)

ORDER CIDAROIDA CLAUS, 1880

Only three species belonging to this order have been collected in the Gulf of Mexico, but an additional nine species are included in the key since they have been recorded from nearby waters (Table 2).

KEY TO CIDAROIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

(Modified from Phelan, 1970)

1. Ambital and aboral primary spines long, smooth, with or without spinules; oral primary spines curved slightly toward mouth, flattened, strongly serrate; primary tubercles strongly crenulate 2
1. Primary spines rough, or, if smooth, oral primaries not curved nor strongly serrate; primary tubercles crenulate or non-crenulate 4
2. Primary spines with long collar (two or more times diameter of spine), often swollen, purple*Porocidaris purpurata* (Wyville-Thomson)
2. Primary spines with short collar (less than two times diameter of spine) 3
3. Interradial suture bare; generally one brown secondary spine on each ambulacral plate*Histocidaris sharreri* (A. Agassiz)
3. Interradial suture with small secondary spines; generally two white secondary spines on each ambulacral plate*Histocidaris nuttingi* Mortensen
4. Large globiferous pedicellariae, each with single distinct end tooth (Figure 2d, e) 5
4. Large globiferous pedicellariae, without single distinct end tooth 9
5. Blades of large globiferous pedicellariae with very small opening distally (Figure 2e); primary spines with distinct banding pattern*Tretocidaris bartletti* (A. Agassiz)
5. Blades of large globiferous pedicellariae with large opening distally (Figure 2d); primary spines not banded (except some juvenile *Stylocidaris affinis*) 6
6. Primary spines above and below ambitus very smooth, without spinules, long, shiny, white with reddish collar*Calocidaris micans* (Mortensen)
6. Primary spines above and below ambitus with spinules, not shiny, without reddish collar; spines above ambitus may be smooth with very reduced spinules 7
7. Primary spines above ambitus often smooth with reduced spinules, those below ambitus with noticeable longitudinal ridges; primary spines generally white*Cidaris abyssicola* (A. Agassiz)
7. Primary spines brownish, all with well-developed spinules 8

8. Primary spines above ambitus fan-shaped *Cidaris blakei* (A. Agassiz)
8. Primary spines above ambitus round in cross-section (on larger specimens, occasionally flattened distally, never fan-shaped) *Cidaris rugosa* (H. L. Clark)
9. Perradial area and all interambulacral sutures naked 10
9. Perradial area not naked; either horizontal or vertical interambulacral sutures not naked 11
10. Naked reddish-brown ring in apical system; perradial suture reddish-brown; scrobicular spines white, without midline stripe *Stylocidaris lineata* Mortensen
10. No naked reddish-brown ring in apical system; perradial suture not red; scrobicular spines with reddish-brown midline stripe *Stylocidaris affinis* (Philippi)
11. Primary spines with well-developed rows of spinules, uppermost row commonly forming conspicuous crest; spine tips not crown-like *Stereocidaris ingolfiana* Mortensen
11. Primary spines with wart-like spinules, no conspicuous crest; spine tips crown-like *Eucidaris tribuloides tribuloides* (Lamarck)

Family Cidaridae Gray, 1825

Eucidaris tribuloides tribuloides (Lamarck, 1816)

Figure 3

Cidarites tribuloides Lamarck, 1816, p. 56.

Cidaris tribuloides: L. Agassiz and Desor, 1846, p. 326; A. Agassiz, 1872, pp. 99, 253, pl. 1d, pl. 2, figs. 1-3, pl. 2c, fig. 13; 1883, p. 9; Rathbun, 1885, p. 609; 1886, p. 260; Ives, 1891, p. 337; H. L. Clark, 1898, p. 412; 1899, p. 131; 1901a, p. 344; 1901b, p. 252; A. Agassiz and H. L. Clark, 1907, p. 3, pl. 2, figs. 1-4.

Cidaris annulata: A. Agassiz, 1869, p. 253 [not *Cidaris annulata* Gray, 1855].

Eucidaris tribuloides: Jackson, 1914, p. 141; H. L. Clark, 1918, p. 17; 1921, p. 105; Mortensen, 1928, p. 400, pl. 41, figs. 9-16, pl. 48, fig. 1, pl. 73, fig. 1, pl. 86, fig. 16; Tortonese, 1933, p. 105; A. H. Clark, 1954, p. 374; Mayr, 1954, p. 3, fig. 1; Moore, 1958, p. 155; Kornicker et al., 1959, p. 21; Caso, 1961, p. 226, text-figs. 91, 92; Lewis, 1961, p. 52; Kier and Grant, 1965, p. 12, pl. 2, figs. 1-3; Cutress, 1965, p. 797; Kier, 1966, p. 6; Tommasi, 1966b, p. 6, pl. 1a; Randall, 1967, pp. 771, 803, 821; Roa, 1967, p. 298; McPherson, 1968a, p. 400; 1968b, p. 308; Phelan, 1970, p. 12, pl. 1, figs. 1, 2, 5, pl. 16, figs. 1-5, pl. 17, figs. 1-7, pl. 18, figs. 1-3; Chesher, 1972, p. 151; Percharde, 1972, pp. 86, 88, fig. 2A; Godcharles and Jaap, 1973, p. 51; Burke, 1974, p. 315, fig. 11; Avent et al., 1977, p. 200; Hopkins et al., 1977, p. 35.

Material examined: HOURGLASS STATION C: 1, 55.4 mm; 19 November 1965; dredge; FSBC I 1219. — 1, 51.0 mm; 18 October 1966; trawl. — 1, 8.0 mm; 19 November 1966; dredge. — 1, 8.0 mm; 13 December 1966; dredge; FSBC I 11093. — 1, 8.6 mm; 6 January 1967; dredge. — 1, 11.2 mm; 5 February 1967; dredge; FSBC I 11094. — 1 damaged, about 11 mm; 5 February 1967; trawl. — 1, 12.6 mm; 2 March 1967; dredge; FSBC I 6767. — 1, 52.4 mm; 11 August 1967; trawl; FSBC I 6789. — 1 adult; 11 September 1967; dredge; FSBC I 11095. — HOURGLASS STATION D: 1, 3.8 mm; 9 October 1966; trawl; FSBC I 4562. — 1, 4.6 mm; 9 October 1966; dredge; FSBC I 4573. — 1, 9.5 mm; 27 October 1967; trawl; FSBC I 6771. — 1, 2.0 mm; 27 October 1967; dredge; FSBC I 11096. — HOURGLASS STATION E: 1, 2.2 mm; 9 October 1966; dredge; FSBC I 4611. — HOURGLASS STATION K: 1, 49.1 mm; 4 September 1965; FSBC I 877. — fragments; 6 December 1966; dredge; FSBC I 11092. — HOURGLASS STATION L: 5, 29.1-43.2 mm; 4 September 1965; trawl; FSBC I 882. — 2 adults; 4 September 1965; dredge. — 6, 30.7-36.7 mm; 13 October 1965; trawl; FSBC I 944. — 8, 34.0-45.0 mm; 13 October 1965; dredge. — 2, 28.5, 29.1 mm; 13

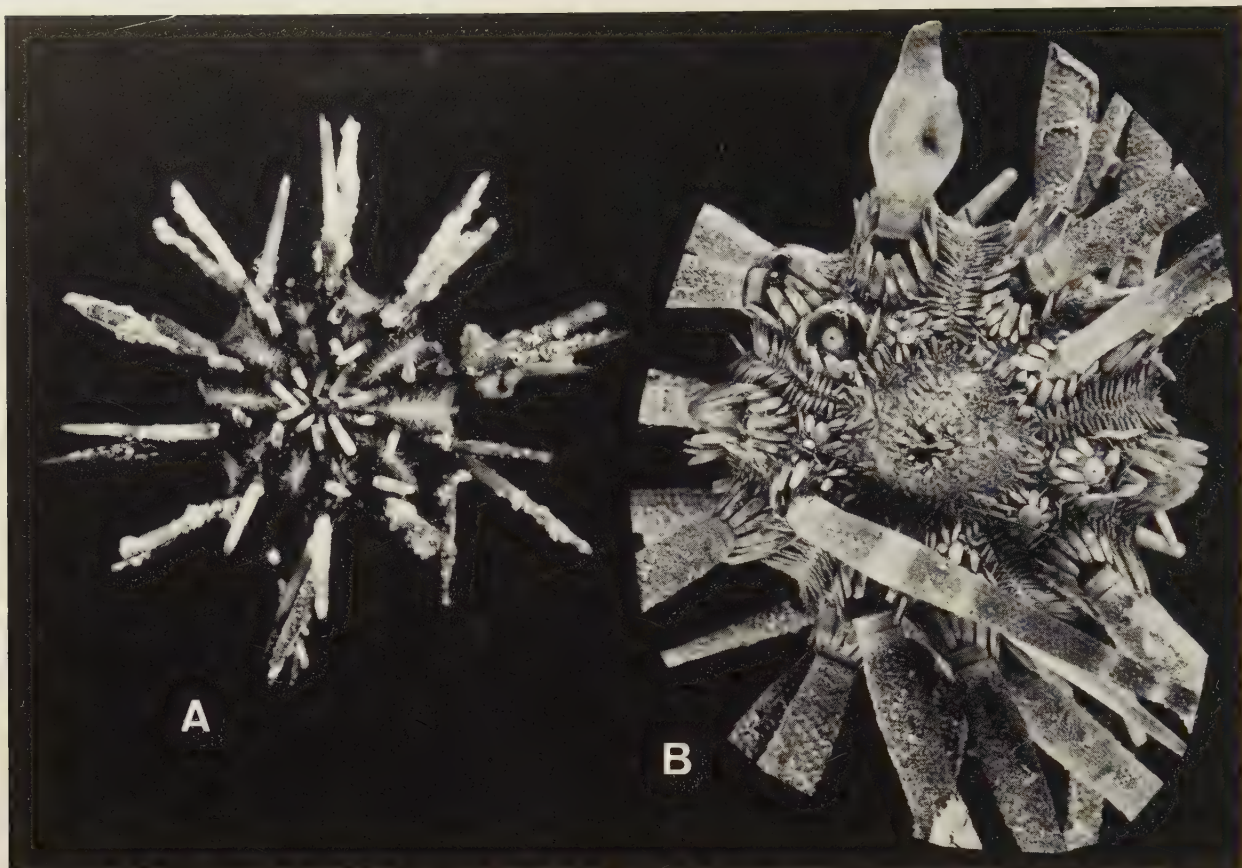


Figure 3. *Eucidaris tribuloides tribuloides*: A, oral aspect, 51 mm HD; southwest of Egmont Key, 27°20'N, 83°46'W, 48 m; FSBC I452; B, aboral aspect, 32 mm HD; Station L, June 1967; USNM E15211 (note primary spine with gall of *Mucronalia nidorum*).

November 1965; trawl; FSBC I 1181. — 3, 25.0-42.0 mm; 13 November 1965; dredge. — 1, 29.0 mm; 13-14 December 1965; trawl. — 2, 34.0, 39.0 mm; 13-14 December 1965; dredge. — 2, 34.0, 40.0 mm; 15 February 1966; trawl. — 2, 26.0, 34.0 mm; 15 February 1966; dredge. — 1, 40.0 mm; 22 March 1966; trawl. — 2, 30.0, 32.0 mm; 22 March 1966; dredge. — 4, 23.0-38.0 mm; 12 April 1966; trawl. — 1, 32.0 mm; 12 April 1966; dredge. — 2, 34.0, 40.0 mm; 12 May 1966; trawl. — 5, 27.0-42.0 mm; 13 June 1966; trawl. — 5, 29.0-36.0 mm; 13 June 1966; dredge. — 1, 29.0 mm; 6 July 1966; dredge. — 5, 31.0-35.0 mm; 6 August 1966; dredge. — 6, 3.0-31.0 mm; 5 September 1966; dredge; FSBC I 4101. — 2, 3.7, 36.0 mm; 13 October 1966; dredge. — 1 adult; 16 February 1967; dredge. — 1, 12.1 mm; 16 May 1967; dredge. — 1, 6.4 mm; 7 June 1967; trawl. — 6 adults; 7 June 1967; dredge. — 1 adult; 6 July 1967; dredge. — 1, 13.4 mm; 8 August 1967; dredge. — 1, 10.3 mm; 5 September 1967; trawl. — 5 adults; 5 September 1967; dredge. — 1, 10.2 mm; 15 November 1967; trawl. — 2, 4.1, 14.7 mm; 15 November 1967; dredge. — HOURGLASS STATION M: 7, 2.6-4.2 mm; 5 September 1966; dredge; FSBC I 4548. — 1, 9.3 mm; 9 March 1967; dredge. — 2, 8.0, 8.2 mm; 5 September 1967; trawl; FSBC I 11162. — 1, 8.4 mm; 5 September 1967; dredge.

Diagnosis: Tubercles non-crenulate; globiferous pedicellariae without large single end tooth; test flattened adapically; ambulacral midline tuberculate; primary spines short, stout, ending in crown-like tips; interambulacral sutures not naked; scrobicular spines with broad, blunt tips and no median stripes.

Distribution: *Eucidaris t. tribuloides* occurs from Cape Hatteras, North Carolina and Bermuda, throughout the Gulf and Caribbean, and south to Rio de Janeiro, Brazil. It occurs in depths from 0 to 800 m, but is most

common in less than 50 m. *Eucidaris t. africana* Mortensen, 1909, is known from the Gulf of Guinea and the Cape Verde Islands.

Bottom type: According to McPherson (1968a) this species is often in rock crevices during the day, but he observed specimens moving short distances from rocks at night. Kier and Grant (1965) report this species from rocky areas and turtle grass (*Thalassia testudinum* König) beds. In the Hourglass area, it occurred at offshore Stations C, D, E, K, L and M (Table 3), where numerous limestone outcroppings were present.

TABLE 3. NUMBERS OF *EUCIDARIS T. TRIBULOIDES* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Eucidaris tribuloides tribuloides																																	
STA	1965					1966															1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J	sp	A	S	O	N	D	J	J	sp	F	M	A	M	J	J	A	S	O	N	
A																																	
B ₁																																	
B ₂																																	
C ₁																																	
C ₂				1																1		2	1										4
D ₁																																	6
D ₂																																	2
E																																	2
I																																	1
J																																	
K		1																															1
L		7	14	5	3		4	3	5	2	10	1		5	6	2	1	2	2		1				1	7	1	1	6		3	92	
M															7								1										11
TOT	8	14	6	3		4	3	5	2	10	1		5	13	6	2	3	3		3	2		1	7	1	2	10	2	3		119		

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Diet: Pieces of algae and bryozoans were found in the gut of *E. t. tribuloides* by Mortensen (1928). McPherson (1968a) reported that gut contents of specimens from near Miami, Florida consisted primarily of calcium carbonate fragments, including fragments from corals, gastropod shells, foraminiferans and echinoid spines. Algal and sponge remains also occurred in the gut. In laboratory studies, McPherson (1968b) found that *E. t. tribuloides* preferred rock infested with the boring sponge, *Cliona lampa* deLaubenfels, over turtle grass, algal-covered rocks, and strips of fish (mullet). He observed that the urchins fed primarily on the rock surface where the sponge tissue was most concentrated. The ash-free weight of sponge infested rock consumed daily corresponded to roughly five percent of the ash-free weight of the urchin.

Growth and reproduction: McPherson (1968a) compared growth of *E. t. tribuloides* from aquaria, an offshore patch reef (Margot Fish Shoal), and an inshore area of turtle grass, sand and rocks (Sewage Beach). Growth rates were all significantly different, being greatest in aquarium specimens and least in specimens from Margot Fish Shoal. At the end of one year's growth, mean horizontal test diameter was about 15 mm at all three environments. However, at the end of two years, aquarium specimens were about 36 mm HD, Sewage Beach specimens were about 30 mm HD, and Margot Fish Shoal specimens were only about 23 mm HD. At three years of age, these values were approximately 44, 38 and 27 mm HD, respectively, and at four years they were 48, 42 and 29 mm HD, respectively. He found growth rates decreased in summer, probably as a result of gonad development. At any point in time, McPherson found no difference in growth rates in specimens held at 18, 22 and 26°C. However, variation in test growth may have obscured a correlation with temperature.

Some individuals have ripe gonads at 20 mm HD, but spawning generally occurs during the second year (McPherson, 1968a). McPherson found spawning occurred from mid-October to mid-November in

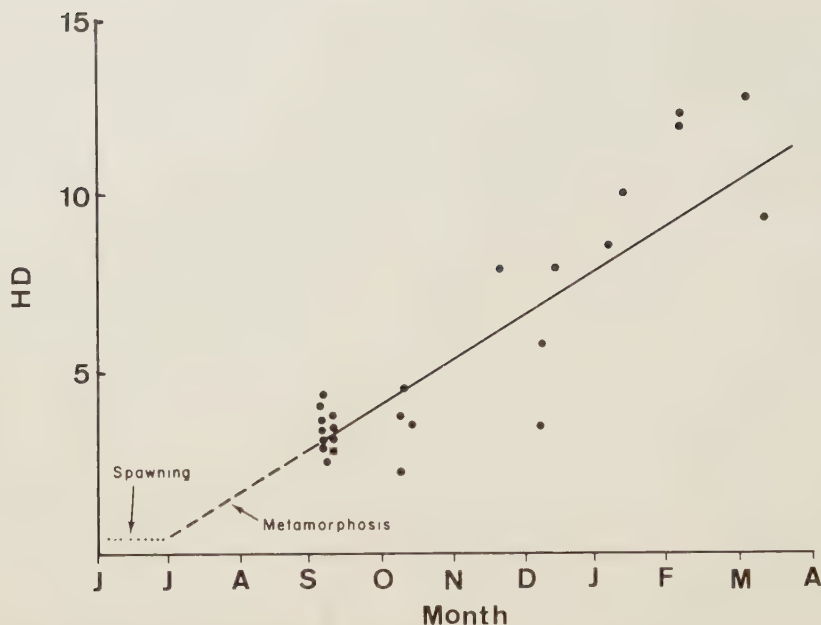


Figure 4. Horizontal diameter, 25 *E. t. tribuloides* juveniles collected June 1966-April 1967. Solid line calculated by least square regression. Dashed line extrapolates to size at metamorphosis (0.4 mm HD); dotted line indicates 25 day larval period.

1965, while gonad indices showed an earlier spawning from July to September in 1966. Figure 4 shows the HD of Hourglass juveniles collected from June 1966 through April 1967. The larval stage lasts for about 25 days, and specimens after metamorphosis are 0.4 mm HD (McPherson, 1968a). Assuming the same rate of growth for specimens smaller than 3 mm HD, metamorphosis must have occurred sometime in July and spawning in June at Hourglass stations during 1966.

Gear selectivity: The dredge was more efficient in collecting this species; 79 specimens were collected by dredge and 40 by trynet.

Morphometric and meristic relationships: Six measurements and two counts were taken on 54 specimens ranging from 3 to 57 mm HD. Linear regression data for various characters as a function of HD are presented in Table 4.

McPherson (1968a) examined test shape of *E. t. tribuloides* from different habitats near Miami. He looked at three characters (TH, PS and AS) as functions of HD and found that specimens from a rocky offshore area (Margot Fish Shoal and Long Reef) had relatively higher tests, larger peristomes and smaller apical systems than specimens from an offshore muddy bottom (Alligator Reef) and an inshore turtlegrass-sand-rock bottom (Sewage Beach). Test height (TH) in Hourglass specimens differs from the four populations examined by McPherson near Miami. He only provides a visual indication of variation so his data cannot be statistically compared to Hourglass data. However, a visual comparison of the linear regression lines indicates the slope is generally less and the y-intercept is generally larger in the Hourglass population. Diameter of the peristome (PS) for Hourglass specimens was nearly identical to values given for populations at Alligator Reef and Sewage Beach, and was relatively smaller than values given for Margot Fish Shoal and Long Reef. Similarly, diameter of the apical system (AS) was similar to that given by McPherson for populations at Alligator Reef and Sewage Beach. The population at Margot Fish Shoal had a relatively large apical system, while specimens from the similar habitat at Long Reef had a relatively small apical system. There are probably some habitat differences that could account for this disparity, but no explanation was offered by McPherson. Since test morphology varies within different habitats at a given locality, McPherson correctly points out that habitats must be considered when comparing widely separated

TABLE 4. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS
AS A FUNCTION OF HD IN *E. TRIBULOIDES TRIBULOIDES**.

Character	Regression Equation	$s_{y.x}$	r
TH	$y = 0.59x - 1.27$	1.08	0.99
AS	$y = 0.35x + 1.48$	0.84	0.99
PP	$y = 0.19x + 0.62$	0.56	0.98
IA	$y = 0.11x + 4.14$	0.44	0.97
AMB	$y = 1.44x + 7.79$	2.64	0.99
AD	$y = 0.13x + 0.66$	0.51	0.97
PS	$y = 0.36x + 1.32$	0.60	0.99

*All characters (ordinates) plotted as function of HD (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 54.

(geographically) populations of *Eucidaris*. He examined specimens from a shallow reef off Cartagena and a shallow, rocky area at Ascension. These habitats are most similar to those at Margot Fish Shoal and Long Reef, and when statistical comparisons were made, no significant differences were found between these four populations. Specimens from deeper water (6 to 69 m) off west Africa were most similar to specimens from deeper water off Alligator Reef. Thus, it appears that test shape varies more between different habitats within a small geographic area than between similar habitats from widely separated areas.

Predators and parasites: McPherson (1968a) observed the gastropod, *Charonia variegata* (Lamarck), feeding on *E. t. tribuloides* at Margot Fish Shoal and in aquaria. The gastropod, *Cypraecassis testiculus* (Linné), and the stone crab, *Menippe nodifrons* Stimpson, were observed feeding on *E. t. tribuloides* in aquaria, but not in nature. According to J. E. Randall (cited as a personal communication in McPherson) remains of *E. t. tribuloides* were found in stomachs of the following fishes: *Balistes vetula* Linné, *Diodon hystrix* Linné, *D. holocanthus* Linné, *Anisotremus surinamensis* (Bloch), *Haemulon plumieri* (Lacépède), *Halichoeres radiatus* (Linné) and *Lachnolaimus maximus* (Walbaum). However, Randall believed that the species is probably not a major dietary item in any of these fishes. McPherson observed the Spanish hogfish, *Bodianus rufus* (Linné), feeding on *E. t. tribuloides* at Margot Fish Shoal, but only after he had dislodged the urchins from beneath rocks.

Pilsbry (1956) and McPherson (1968a) reported that a small gastropod, *Mucronalia nidorum* Pilsbry, bores into primary spines of *E. t. tribuloides*, causing galls 4 to 6 mm in diameter. Similar galls were found in a few Hourglass specimens, and W. G. Lyons identified *M. nidorum* from specimens of *E. t. tribuloides* collected in the northeastern Gulf of Mexico.

Remarks: McPherson (1968a, b) reported urchin densities as high as 2/m².

Stylocidaris affinis (Philippi, 1845)

Figure 5

Cidaris affinis Philippi, 1845, p. 351.

Dorocidaris pappillata: Rathbun, 1885, p. 611; 1886, p. 261; A. Agassiz and H. L. Clark, 1907, p. 8, pl. 12b, figs. 1-3 [not *Dorocidaris pappillata* (Leske, 1778)].

Stylocidaris affinis: H. L. Clark, 1918, p. 19; 1922, p. 361; Mortensen, 1928, p. 336, pl. 36, figs. 1-7, pl. 72, fig. 15; Tortonese, 1933, p. 105; A. H. Clark, 1954, p. 374; Lewis, 1961, p. 52; 1963, p. 360; Tommasi, 1966b, p. 6, pl. 1b; Phelan, 1970, p. 19, pl. 18, figs. 4-6, pl. 19, figs. 1, 3, 7, pl. 20, figs. 4, 5; Burke, 1974, p. 315, fig. 10; Avent et al., 1977, p. 200.

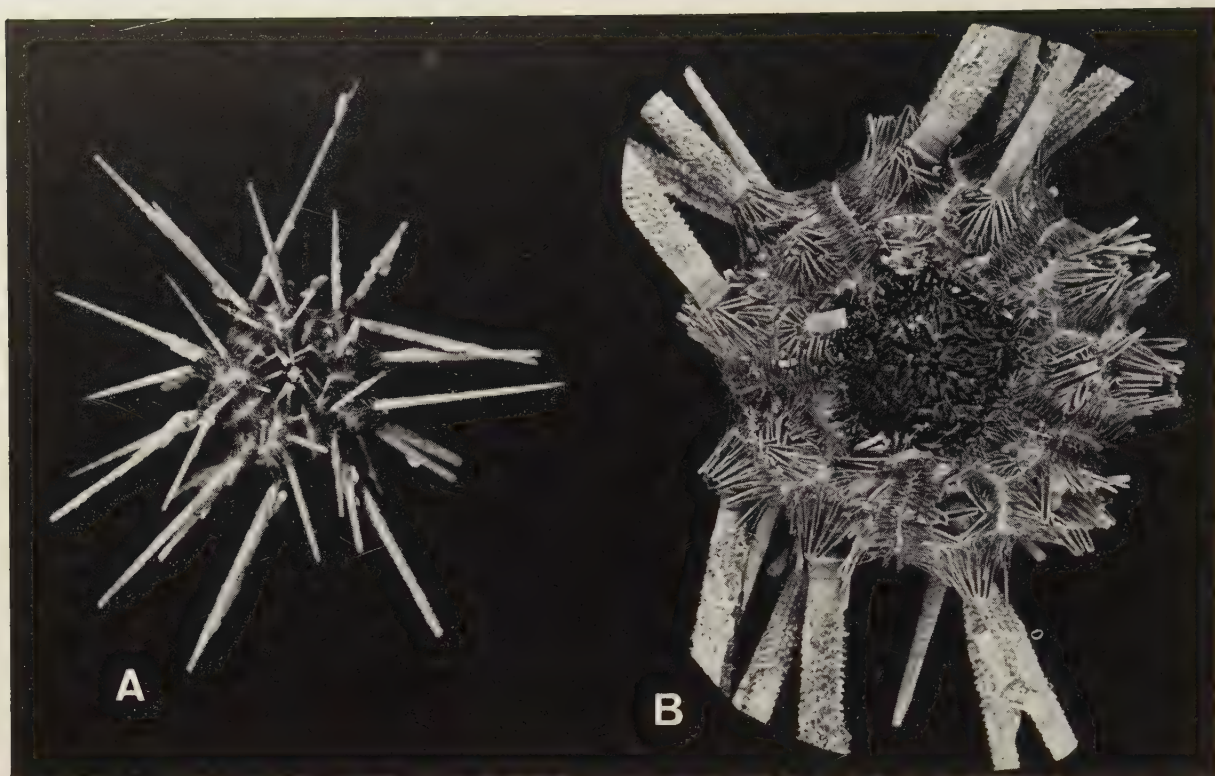


Figure 5. *Stylocidaris affinis* A, oral aspect, 35 mm HD; north of Dry Tortugas, 25°19'N, 83°24'W, 64 m; FSBC I 752; B, aboral aspect, 29 mm HD; Station L, October 1965; FSBC I 945.

Material examined: HOURGLASS STATION D: 1, 16.0 mm; 3 May 1966; dredge. — 1, 9.0 mm; 3 May 1966; trawl. — HOURGLASS STATION E: 3, 11.9-17.0 mm; 4 August 1965; dredge; FSBC I 754. — 3, 6.2-13.2 mm; 31 August 1965; trawl; FSBC I 852. — 2, 2.4, 7.8 mm; 5 October 1965; trawl; FSBC I 925. — 1, 5.7 mm; 5 October 1965; dredge; FSBC I 932. — 1, 2.6 mm; 9 November 1965; dredge. — 6, 8.9-18.3 mm; 4 December 1965; trawl; FSBC I 1381. — 1, 12.0 mm; 4 December 1965; dredge. — 2, 3.9, 7.9 mm; 4 January 1966; dredge; FSBC I 1617. — 3, 5.8-30.0 mm; 8 February 1966; trawl. — 1, 12.0 mm; 8 February 1966; dredge. — 1, 3.8 mm; 4 March 1966; trawl. — 1, 17.0 mm; 7 April 1966; dredge. — 4, 8.0-10.0 mm; 7 June 1966; trawl. — 7, 7.0-23.0 mm; 7 June 1966; dredge. — 1, 13.0 mm; 3 July 1966; trawl. — 7, 6.0-11.0 mm; 2 August 1966; trawl. — 1, 10.0 mm; 2 August 1966; dredge. — 8, 7.0-13.0 mm; 9 October 1966; trawl. — 27, 2.1-22.7 mm; 9 October 1966; dredge. — 20, 2.4-16.0 mm; 9 November 1966; trawl. — 9, 2.8-14.3 mm; 9 November 1966; dredge. — 4, 7.7-15.5 mm; 2 December 1966; trawl. — 3, 12.4-23.0 mm; 6 February 1967; trawl. — 1, 3.2 mm; 3 March 1967; trawl. — 7, 4.0-18.4 mm; 3 March 1967; dredge. — 2, 6.5, 17.2 mm; 12 May 1967; trawl. — 4, 4.9-20.2 mm; 12 May 1967; dredge. — 3, 15.7-20.5 mm; 2 August 1967; dredge. — 1, 9.1 mm; 1 September 1967; trawl. — 1, 10.1 mm; 6 October 1967; trawl. — 3, 2.4-22.0 mm; 6 October 1967; dredge. — 7, 11.2-17.0 mm; 3 November 1967; trawl. — 7, 3.5-17.0 mm; 3 November 1967; dredge. — HOURGLASS STATION I: 1, 13.0 mm; 6 June 1967; trawl; FSBC I 11098. — HOURGLASS STATION K: 31, 1.0-1.5 mm; 14 November 1967; dredge; FSBC I 11100. — HOURGLASS STATION L: 11, 20.6-35.3 mm; 4 September 1965; trawl; FSBC I 881. — 1 adult; 4 September 1965; dredge. — 2, 29.2, 36.9 mm; 13 October 1965; trawl; FSBC I 945. — 4, 30.0-40.0 mm; 13 October 1965; dredge. — 2, 27.9, 29.2 mm; 13 November 1965; trawl; FSBC I 1182. — 4, 10.0-32.0 mm; 13-14 December 1965; trawl. — 1, 26.0 mm; 13-14 December 1965; dredge. — 1, 11.0 mm; 14 January 1966; dredge. — 2, 30.0, 33.0 mm; 15 February 1966; trawl. — 3, 23.0-33.0 mm; 15 February 1966; dredge. — 3, 10.0-32.0 mm; 22 March 1966; trawl. — 1, 26.0 mm; 22 March 1966; trawl. — 1, 26.0 mm;

22 March 1966; dredge. — 1, 28.0 mm; 12 April 1966; trawl. — 1, 28.0 mm; 12 April 1966; dredge. — 2, 25.0, 32.0 mm; 13 June 1966; trawl. — 3, 24.0-28.0 mm; 13 June 1966; dredge. — 1, 44.0 mm; 6 July 1966; trawl. — 1, 33.0 mm; 6 July 1966; dredge. — 1, 27.8 mm; 16 February 1967; trawl; FSBC I 11097. — 1, 28.9 mm; 16 February 1967; dredge. — fragments; 16 May 1967; trawl. — 3, 2.1-13.0 mm; 8 August 1967; dredge. — 1, 38.3 mm; 5 September 1967; trawl; FSBC I 6577. — 1, 31.7 mm; 15 November 1967; trawl. — HOURGLASS STATION M: 5, 9.5-27.6 mm; 13 October 1965; trawl; FSBC I 954. — 1, 8.0 mm; 13 October 1965; dredge. — 1, 19.0 mm; 13 November 1965; dredge. — 2, 7.0, 18.0 mm; 14 January 1966; trawl. — 3, 3.7-24.0 mm; 14 January 1966; dredge. — 2, 2.8, 7.1 mm; 15 February 1966; trawl; FSBC I 2061. — 2, 25.0, 27.0 mm; 22 March 1966; trawl. — 2, 7.0, 9.0 mm; 12 April 1966; trawl. — 6, 4.0-11.0 mm; 12 April 1966; dredge. — 1, 23.0 mm; 12 May 1966; trawl. — 1, 29.0 mm; 13 June 1966; trawl. — 5, 9.0-29.0 mm; 6 July 1966; trawl. — 2, 6.0, 7.0 mm; 6 July 1966; dredge. — 7, 6.2-8.5 mm; 6 August 1966; dredge; FSBC I 3728. — 24, 5.0-25.0 mm; 5 September 1966; trawl. — 48, 1.8-31.2 mm; 5 September 1966; dredge; FSBC I 4547. — 2, 9.5, 13.8 mm; 13 November 1966; trawl. — 10, 8.0-14.7 mm; 13 November 1966; dredge. — 2, 9.4, 14.1 mm; 7 December 1966; trawl. — 13, 8.1-10.1 mm; 7 December 1966; dredge. — 1, 13.4 mm; 13 January 1967; dredge. — 1, 15.6 mm; 16 February 1967; dredge. — 3, 10.5-13.7 mm; 9 March 1967; dredge. — 1, 4.8 mm; 8 April 1967; dredge. — 2, 14.9, 18.7 mm; 16 May 1967; trawl. — 2, 6.1, 25.0 mm; 6 July 1967; trawl. — 5, 6.7-15.4 mm; 6 July 1967; dredge. — 19, 4.4-26.2 mm; 5 September 1967; trawl. — 6, 1.6-10.7 mm; 5 September 1967; dredge. — 1, 32.9 mm; 12 October 1967; dredge; FSBC I 11099. — 1, 7.1 mm; 15 November 1967; trawl. — 1, 2.3 mm; 15 November 1967; dredge.

Diagnosis: Tubercles non-crenulate; globiferous pedicellariae without a single, large end tooth; perradial area naked; interambulacral sutures naked; scrobicular spines with reddish midline stripe.

Distribution: In the western North Atlantic, *S. affinis* occurs off Maryland and Bermuda, south along the continental east coast and Bahamas, around the tip of Florida to the Flower Gardens off Texas, through the Greater and Lesser Antilles, and along the coasts of Venezuela and Colombia. In the eastern North Atlantic it is known from the Mediterranean Sea, off Portugal, the Canary Islands and the Cape Verde Islands. It is known from 23 to 1000 m, but is most common from 50 to 200 m.

Bottom type: Specimens in this study were usually found on a substrate composed primarily of algal sand (*Lithothamnion* spp.) at deeper Stations E, L and M (Table 5).

Diet: Gut contents reported by Mortensen (1928) and confirmed by this study were broken shell and bryozoans. According to Lewis (1963), gut contents of specimens from Barbados included sand grains, foraminiferans and small gastropods. He also found sponge fragments in one specimen.

Growth and reproduction: A general summer spawning time is inferred, since young juveniles were present in the Hourglass samples throughout the summer and fall. Size frequency plots provided little useful information concerning growth. Mortensen (1928) found that genital pores of eastern Atlantic specimens developed between 8 and 11 mm HD. Specimens from this study developed genital pores at slightly larger sizes, between 10.1 and 12.2 mm HD. The largest specimen obtained in this study was 43 mm HD, just 1 mm smaller than the largest known specimen.

Population dynamics: Populations at Stations E and M were relatively stable throughout the study, with recruitment occurring in all three years. Only two specimens were ever collected at Station D, and only 31 recently metamorphosed specimens 1.0 to 1.5 mm HD were collected at Station K during the last month of

TABLE 5. NUMBERS OF *STYLOCIDARIS AFFINIS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Stylocidaris affinis																																
STA	1965					1966													1967													TOT
	A	S	O	N	D	J	F	M	A	M	J	J	Jsp	A	S	O	N	D	J	Jsp	F	M	A	M	J	J	A	S	O	N		
A																																
B ₁																																
B ₂																																
C ₁																																
C ₂																																
D ₁										2																					2	
D ₂																																
E	3	3	3	1	7	2	4	1	1		11	1		8		35	29	4			3	8		6			3	1	4	14	152	
I																									1						1	
J																																
K																													31		31	
L		12	6	2	5	1	5	4	2		5	2									2						3	1		1	51	
M			6	1		3	2	2	8	1	1	7		7	72		12	15	1		1	3	1	2		7		25	1	2	180	
TOT	3	15	15	4	12	6	11	7	11	3	17	10		15	72	35	41	19	1		6	11	1	8	1	7	6	27	5	48	417	

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

sampling. The specimen from Station I (6 m) was probably overlooked in the net at Station E, the last station previously sampled. The population at Station L was composed primarily of large adults with very little observable recruitment. Catch per unit effort (one 15 min dredge sample plus one 30 min trynet sample) at Station L decreased from 4.8 individuals per month in 1965 to 1.7 individuals in 1966 and to 0.6 individuals in 1967. The decrease was probably related to sparse recruitment. Stations D, K and L appear to contain marginal, shallow-water populations fluctuating greatly from year to year, while deeper water populations at Stations E and M appear relatively stable.

Gear selectivity: The dredge was more efficient in collecting this species; 239 specimens were collected by dredge and 180 by trynet.

Meristic and morphometric relationships: Six measurements and two counts were taken on 58 *S. affinis* ranging from 3 to 38 mm HD. Linear regression data for various characters as a function of HD is presented in Table 6.

TABLE 6. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS AS A FUNCTION OF HD IN *S. AFFINIS**.

Character	Regression Equation	$s_{y.x}$	r
TH	$y = 0.60x - 1.17$	0.64	0.99
AS	$y = 0.58x + 0.44$	0.44	1.00
PP	$y = 0.26x - 0.06$	0.35	0.99
IA	$y = 0.10x + 4.38$	0.31	0.95
AMB	$y = 1.49x + 8.29$	2.12	0.99
AD	$y = 0.16x + 0.34$	0.24	0.99
PS	$y = 0.36x + 1.14$	0.52	0.99

*All characters (ordinates) plotted as function of HD (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 58.

ORDER ECHINOTHUROIDA CLAUS, 1880

Four species and one additional subspecies belonging to this order have been collected in the Gulf of Mexico, and another species has been recorded from nearby waters (Table 2). All typically occur at depths greater than those sampled during the Hourglass Cruises.

KEY TO ECHINOTHUROIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Adoral primary spines club-shaped, enclosed in thick bag of skin; compound ambulacral plates on oral surface composed of large, central primary plate, with a smaller secondary plate above and below, all in contact with interambulacral plates (Figure 2h) 2
1. Adoral primary spines tipped with smooth, shiny, white hoof; compound ambulacral plates with one or no secondary plate in contact with adjacent interambulacral plates 3
2. Primary tubercles present around apical system within an imaginary circle with radius extending half-way to ambitus*Phormosoma placenta placenta* Wyville-Thomson
2. Primary tubercles absent from an imaginary circle with radius extending half-way to ambitus*Phormosoma placenta sigsbei* A. Agassiz
3. Ambulacral pores arranged in single irregular series on oral side ... *Hygrosoma petersii* (A. Agassiz)
3. Ambulacral pores arranged in three series on oral side 4
4. Compound ambulacral plate of oral surface composed of four plates, three adradial perforate and one perradial imperforate*Sperosoma antillense* Mortensen
4. Compound ambulacral plate of oral surface composed of three perforate plates 5
5. Small tridentate pedicellariae strongly involute (Figure 2f)*Araeosoma belli* Mortensen
5. Small tridentate pedicellariae scarcely involute (Figure 2g)*Araeosoma fenestratum* (Wyville-Thomson)

ORDER DIADEMATOIDA DUNCAN, 1889

Four species belonging to this order have been collected in the Gulf of Mexico, and another species has been recorded from nearby waters (Table 2).

KEY TO DIADEMATOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Test height about equal to width 2
1. Test height less than half width 3
2. Ambulacral plates simple; primary tubercles on interambulacral plates only*Plesiadiadema antillarum* (A. Agassiz)
2. Ambulacral plates compound; primary tubercles on ambulacral and interambulacral plates*Aspidodiadema jacobyi* A. Agassiz

3. Test flexible; primary spines filled with meshwork *Astropyga magnifica* A. H. Clark
3. Test not flexible; primary spines hollow 4
4. Spines present on buccal plates *Centrostephanus longispinus rubricingulus* H. L. Clark
4. Spines not present on buccal plates *Diadema antillarum* (Philippi)

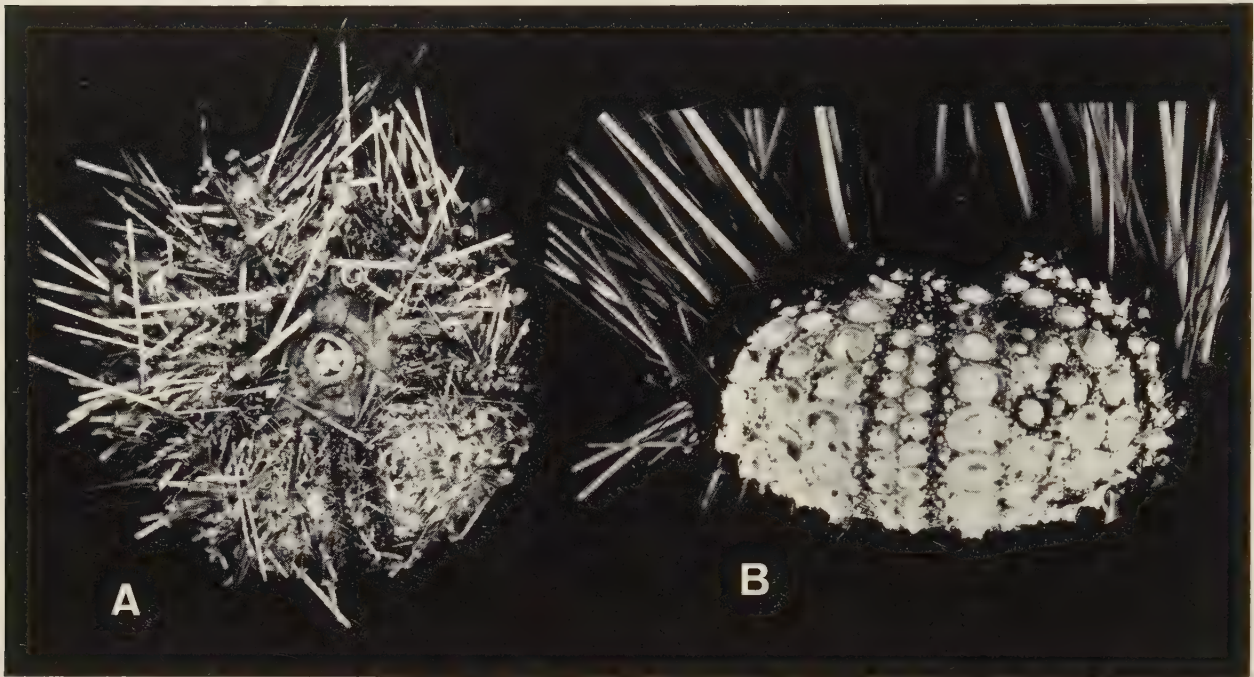


Figure 6. *Diadema antillarum*: A, oral aspect, 90 mm HD; northwest of Sanibel Island, 26°52'N, 83°26'W, 48 m; FSBC I 736; B, lateral aspect, 50 mm HD; St. Thomas, West Indies; USNM 7493.

Family Diadematidae Gray, 1855

Diadema antillarum (Philippi, 1845)

Figure 6

Cidaris (Diadema) antillarum Philippi, 1845, p. 355.

Diadema antillarum: A. Agassiz, 1869, p. 256; A. Agassiz and H. L. Clark, 1908, p. 112; Mortensen, 1910, p. 21; 1921, p. 25, pl. 5, fig. 5; 1931, p. 17; Tortonese, 1933, p. 108; Mortensen, 1940, p. 269, pl. 47, fig. 8, pl. 49, fig. 5, pl. 57, figs. 1-8, pl. 58, figs. 1-6, pl. 73, fig. 21, pl. 74, figs. 4-8; A. H. Clark, 1954, p. 374; Mayr, 1954, p. 8, fig. 7; Moore, 1958, p. 155; Caso, 1961, p. 235, text-fig. 95; Lewis, 1964, p. 549; Randall et al., 1964, p. 421; Kier and Grant, 1965, p. 13, pl. 2, figs. 4-7; Cheshier, 1966, p. 215; Kier, 1966, p. 7, pl. 2, figs. 4, 5; Lewis, 1966, p. 151; Tommasi, 1966a, p. 240; 1966b, p. 11, figs. 6-12; Randall, 1967, pp. 726, 728, 730, 732-734, 750, 764, 766, 769, 771, 774, 799, 803, 814, 818, 819, 821; Roa, 1967, p. 298; Chace, 1969, pp. 266-271, fig. 11g; Snyder and Snyder, 1970, pp. 276-278, fig. 1; Chace, 1972, p. 46; Cheshier, 1972, p. 151; Sammarco, 1972, pp. 1-47; Godcharles and Jaap, 1973, p. 51; Ogden, Abbott and Abbott, 1973, pp. 1-96; Ogden, Brown and Salesky, 1973, pp. 715, 716; Burke, 1974, p. 316, fig. 14; Gooding, 1974, pp. 335, 336; Sammarco et al., 1974, pp. 47-51; Bauer, 1976, pp. 273-277, figs. 1-5; Avent et al., 1977, pp. 97, 98, 207; Hopkins et al., 1977, p. 35.

Diadema setosum: A. Agassiz, 1872, p. 274, pl. 2b, figs. 6-10, pl. 2c, fig. 6, pl. 4a, fig. 1, pl. 6a, fig. 5; 1883, p. 24; Rathbun, 1885, p. 612; Ives, 1890, p. 327; H. L. Clark, 1898, p. 412; 1899, p. 131; 1901b, p. 253; Mayer, 1914, p. 5 [not *Diadema setosum* Gray, 1825].

Centrechinus setosus: Jackson, 1912, pp. 28, 104-109, 152, 155, 167, 168, 184, 191, text-figs. 88-95, 186-189, 211, 219, 220; 1914, pp. 142-147, 158.

Centrechinus antillarum: H. L. Clark, 1918, p. 14; 1921, p. 107; 1922, p. 361; 1933, p. 78; A. H. Clark, 1939, p. 453; Harvey, 1947, p. 217; Lewis, 1961, p. 52.

Material examined: HOURGLASS STATION C: 1, 29.7 mm; 1 August 1966; trawl; FSBC I 3448. — 1, 23.8 mm; 1 August 1966; dredge; FSBC I 3540. — 1, 51.5 mm; 19 November 1966; trawl; FSBC I 4461. — 1, 43.7 mm; 20 January 1967; trawl. — 1, broken; 25 January 1967; trawl. — 1, 94.1 mm; 11 May 1967; trawl; FSBC I 6779. — 1, 45.3 mm; 5 October 1967; trawl; FSBC I 6770. — 4, 6.3-24.5 mm; 2 November 1967; trawl; FSBC I 11067. — 2, 70.4, 94.6 mm; 21 November 1967; trawl. — HOURGLASS STATION D: 1, broken, about 82 mm; 3 May 1966; trawl. — HOURGLASS STATION K: 1, 83.8 mm; 21 March 1966; trawl; FSBC I 2256.

Diagnosis: Test low (less than 50 percent HD); tubercles crenulate, perforate; primary spines hollow; ambulacral plates compound; spines absent from buccal plates; primary tubercles of ambulacrum in two regular series; primary spines banded in juveniles only.

Distribution: *Diadema antillarum* is known in the western Atlantic from the Gulf of Mexico. Bermuda and southeastern Florida to Rio de Janeiro, Brazil. Hopkins et al. (1977) reported it to be the "primary echinoid" at the Florida Middle Ground reefs in the northeastern Gulf of Mexico. In the eastern Atlantic this species is known from the Azores, Madeira, Canaries, Cape Verdes and Annobon Island. It occurs in depths from 0 to 400 m, but is most common in less than 50 m. Avent et al. (1977) reported probable observations of this species from a submersible off central eastern Florida.

Bottom type: According to Randall et al. (1964) and Kier and Grant (1965), *D. antillarum* occurs in numerous habitats such as rock, coral reef, mangrove roots, sea grass beds and sand flats. It rarely occurs in areas where it is exposed to moderate or strong surf, and in deeper water it generally occurs in rock and coral crevices (Randall et al., 1964). Adults tend to be gregarious both for spawning and protection. Juveniles, with their conspicuous purple and white banded spines, are prone to hide whether in deep or shallow water (Randall et al., 1964). Hourglass specimens occurred on bottoms with numerous limestone outcroppings and sand, primarily at Station C.

Diet: *Diadema antillarum* is primarily an herbivore, but a variety of other food items have been found in the gut (Lewis, 1964; Sammarco, 1972). These include coral and shell fragments, sand, mud, foraminiferans and crustaceans. Randall et al. (1964) stated the food habits reflect availability of local plant and detrital food. Ogden, Abbott and Abbott (1973) report similar results, but note some preference for smaller mat-forming and turf-forming plant species. Grazing of *Thalassia* by *D. antillarum* is the major factor involved in formation of halos (denuded or heavily grazed zones) around West Indian patch reefs (Ogden, Brown and Salesky, 1973). Feeding generally occurs in late afternoon and early evening when urchins leave their protected crevices for grass or algae beds (Lewis, 1964; Ogden, Abbott and Abbott, 1973; Ogden, Brown and Salesky, 1973). Sammarco et al. (1974) demonstrated that removal of *D. antillarum* from a patch reef resulted in a great increase in macro-algal biomass, alterations in species composition, shifts in dominance, an increase in species numbers, and a decrease in equitability.

Growth and reproduction: Randall et al. (1964) reported increases in test diameters of 3.5 to 6.7 mm per month in juvenile urchins from the Virgin Islands, but the rates were obtained over short periods (two to three months), and the authors questioned their reliability. Lewis (1966), studying growth in juvenile and adult populations of *D. antillarum* from Barbados, compared growth rates of specimens in nature with others maintained in large concrete tanks. Growth rates were similar, but slightly greater in laboratory-reared specimens. The data indicate that specimens in nature at Barbados attain a size of 25 to 30 mm HD after one year and 45 to 50 mm HD after two years. Growth rates reported by Bauer (1976) for a population off Boca Raton, Florida, were greater, with individuals reaching a size of 35 mm HD after about ten months.

However, Bauer was not able to determine exactly when settlement occurred, and these individuals could be somewhat older.

Several authors have reported spawning periods for *D. antillarum*. Mortensen (1921) stated the species spawned in the West Indies during March and April, in Bermuda in July (Mortensen, 1931), and in Tobago during April and May (Mortensen, 1940). Harvey (1947) stated that *D. antillarum* was ripe in Bermuda from summer through early winter, but no spawning was observed. Randall et al. (1964) reported spawning in winter and early spring in the Virgin Islands, and cited unpublished observations of Ingvar Kristensen that spawning occurs year-round at Curaçao, with a pronounced peak in February and March. Bauer (1976) found that a population at Indian Key in the Florida Keys spawned from October 1968 through January 1969. There appeared to be a lunar periodicity in spawning, with partial release of gametes following the new moon. There seems to be little agreement among workers concerning a spawning time for *D. antillarum*, and it is likely that spawning times are variable from year to year and from population to population.

Predators and commensals: *Diadema antillarum* possesses a sensitive escape response to juices of crushed conspecific sea urchins. Stimulation usually results in urchins moving rapidly downcurrent. Strong species specificity of the response suggests that it is an adaptation to reduce predation (Snyder and Snyder, 1970).

Randall et al. (1964) reported remains of *D. antillarum* in stomachs of the following fish species: *Balistes vetula*, *Canthidermis sufflamen* (Mitchill), *Trachinotus falcatus* (Linné), *Diodon hystrix*, *Bodianus rufus*, *Halichoeres radiatus*, *Lactophrys bicaudalis* (Linné), *Anisotremus surinamensis*, *Haemulon carbonarium* Poey, *H. macrostomum* Günther, *H. plumieri*, *H. sciurus* (Shaw), *Calamus bajonado* (Bloch and Schneider), *C. calamus* (Valenciennes) and *Spheroides spengleri* (Bloch). They also listed three small wrasses, *Halichoeres bivittatus* (Bloch), *H. poeyi* (Steindachner) and *Thalassoma bifasciatum* (Bloch), as having remains of adult *D. antillarum* in their stomachs. However, they believed that the wrasses fed on *Diadema* only after larger fish had opened the tests. In a later paper, Randall (1967) added *Haemulon flavolineatum* (Desmarest), *Calamus pennatula* Guichenot, *Prognathodes aculeatus* (Poey) and *Canthigaster rostrata* (Bloch) as additional species that feed on *Diadema*. Two gastropods, *Cassis madagascariensis* Lamarck and *C. tuberosa* (Linné), and the spiny lobster, *Panulirus argus* (Latreille), are also known to be predators of *D. antillarum*. Schroeder (1962) and Snyder and Snyder (1970) published accounts and photographs of *Cassis tuberosa* pursuing and devouring *Diadema*.

An elongate, black palaemonid shrimp, *Tuleariocaris neglecta* Chace, 1969, was described from spines of *Diadema antillarum*; the shrimp holds on to the spines facing the body and swims head-down from spine to spine or from urchin to urchin (Gooding, 1974). Gooding also reported an undescribed shrimp, *Periclimenes* sp., and an undescribed species of siphonostome cyclopoid copepod, *Asterocheres* sp., common on *D. antillarum* in the northern Gulf of Mexico. He mentioned a grapsid crab, *Percecnion gibbesi* (Milne Edwards), a flatworm, *Syndesmis antillarum* Stunkard and Corlis, a sea anemone, *Aiptasia tagetes* (Duchassaing and Michelotti), and an amphipod, *Lysianassa* sp., as additional associates of *D. antillarum*. Randall et al. (1964) listed several invertebrates and fishes known to swim among spines of *D. antillarum*, including the mysid shrimp, *Mysidium gracile* (Dana), palaemonid shrimps, *Stegopontonia* sp. and *Periclimenes* sp., and the young of many reef fishes, including *Haemulon* spp., *Equetus* spp., Labridae, Chaetodontidae and *Apogon* spp. These may be considered commensals in the broadest sense. Clifton et al. (1970) and Davis (1971) reported that young spiny lobsters, *Panulirus argus*, are often found in close association with groups of *D. antillarum*, presumably for protection. Protozoans, primarily ciliates, have been reported from the digestive tract of *D. antillarum*, but their relationship has not yet been well defined (Randall et al., 1964).

Remarks: Mean urchin densities of 1.2/m² were reported at Matecumbe Key, Florida and 13.4/m² in the Virgin Islands (Randall et al., 1964). Ogden, Brown and Salesky (1973) estimated the population on a 1500 m² patch reef at St. Croix to number between 10,000 and 13,000 individuals. Upper lethal temperatures for *Diadema* were determined to be 37.4 to 37.7°C by Mayer (1914) at Tortugas, Florida.

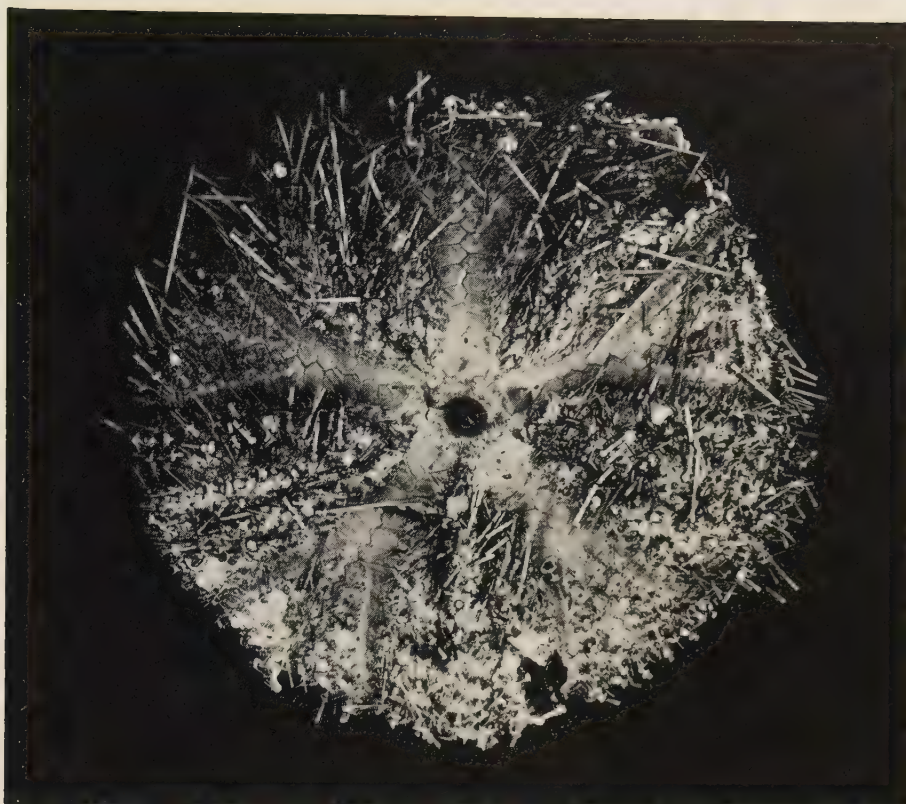


Figure 7. *Astropyga magnifica*, aboral aspect, 139 mm HD; Station L, February 1967; FSBC I 4688.

Astropyga magnifica A. H. Clark, 1934

Figure 7

Astropyga magnifica A. H. Clark, 1934, p. 52; Mortensen, 1940, p. 204, pl. 13, fig. 2, pl. 18, figs. 4-6, pl. 70, figs. 4-6; A. H. Clark, 1954, p. 374; Mayr, 1954, p. 3, fig. 1; Kier and Grant, 1965, p. 15; Chesher, 1972, p. 150; Gooding, 1974, p. 336.

Material examined: HOURGLASS STATION C: 1, 210.0 mm; 2 November 1967; trawl; FSBC I 6801. — HOURGLASS STATION L: 1, 139.0 mm; 16 February 1967; trawl; FSBC I 4688.

Diagnosis: Test low (less than 50 percent HD), flexible; tubercles perforate, crenulate; ambulacral plates compound; primary spines banded, filled with meshwork; interambulacra purplish-red, ambulacra yellowish-white.

Distribution: This species occurs from South Carolina and the southeastern Gulf of Mexico through the Greater and Lesser Antilles to Colombia, Venezuela and Surinam. One of the present specimens extends the range northward in the Gulf to Lat. 27°37'N. It occurs from 11 to 88 m.

Bottom type: In the Florida Keys, Kier and Grant (1965) were able to find specimens only on the sand terrace on the seaward side of a reef. They occurred on flat, grassless sand bounded in places by patches of algae. Hourglass specimens came from Station L, where the bottom was composed primarily of algal sand (*Lithothamnion* spp.), and from Station C, characterized by carbonate sands, crushed shell, and limestone outcroppings.

Diet: Mortensen (1940) reported shell fragments in gut contents.

Commensals: Kier and Grant (1965) observed a cardinal fish (*Apogon* sp.) swimming among the spines of *A. magnifica*. Gooding (1974) reported *Apogon quadrisquamatus* Longley among *A. magnifica* spines at Puerto Rico. He also noted the palaemonid shrimp, *Tuleariocaris neglecta*, living on spines of this urchin, apparently the only reported association of this shrimp on an urchin other than *Diadema antillarum*.

Remarks: This species is highly mobile. Kier and Grant (1965) observed specimens moving across sand flats single-file in groups of two to five, at speeds of approximately 1 m/min. Upon approach of danger, the spines group together into five cone-shaped bundles, thus producing a strong and formidable defense (Kier and Grant, 1965).



Figure 8. *Centrostephanus longispinus rubricingulus*, aboral aspect, 23 mm HD; Station E, October 1966; FSBC I 3950.

Centrostephanus longispinus rubricingulus H. L. Clark, 1921

Figure 8

Centrostephanus rubricingulus H. L. Clark, 1921, p. 108, pl. 1, figs. 1, 2; 1925, p. 52; Mortensen, 1940, p. 308, pl. 36, figs. 3-6, 11, 12, pl. 76, figs. 10-12, 14-18, 22; A. H. Clark, 1954, p. 374; Lewis, 1961, p. 53; Fell, 1975, p. 180.

Material examined: HOURGLASS STATION E: 1, 22.9 mm; 9 October 1966; dredge; FSBC I 3950. — HOURGLASS STATION L: fragments; 13 January 1967; trawl; FSBC I 11107. — 2, 11.0, 38.0 mm; 5 September 1967; trawl; FSBC I 11065. — HOURGLASS STATION M: 1, 9.0 mm; 31 January 1967; trawl; FSBC I 4804. — 1, 10.0 mm; 5 September 1967; trawl; FSBC I 11066.

Diagnosis: Test low (less than 50 percent HD); tubercles crenulate, perforate; primary spines banded, hollow; ambulacral plates compound; spines on buccal plates; primary tubercles of ambulacrum in two regular series.

Distribution: This species is known from off St. Petersburg, Florida in the Gulf and off Miami, Florida in the Atlantic, southward through the Greater and Lesser Antilles to Venezuela. It occurs from 33 to 310 m. The Hourglass specimen from Station E is a northern range extension for the species.

Bottom type: Hourglass specimens came from offshore Stations E, L and M, where bottoms were composed primarily of algal sand (*Lithothamnion* spp.).

Remarks: Mortensen (1940) maintained this as a species distinct from *C. longispinus* (Philippi, 1845) from the eastern North Atlantic and Mediterranean, but stated that the two may be conspecific. Fell (1975) reports that earlier, stronger development of secondary tubercles in the interambulacra noted by Mortensen (1940) for *C. rubricingulus* does not occur in some specimens and does not persist to the adult stage. This eliminates the principal difference between the nominal species, and Fell (1975) suggests that *C. rubricingulus* be reduced to a subspecies of *C. longispinus*.

ORDER PEDINOIDA MORTENSEN, 1939

No species of this order have been collected in the Gulf of Mexico and only one species, *Caenopedina cubensis* A. Agassiz, has been collected from nearby waters (Table 2). The species is quite rare and occurs in depths greater than those sampled during the Hourglass Cruises.

ORDER SALENOIDA DELAGE AND HEROUARD, 1903

One species belonging to this order has been collected in the Gulf of Mexico and two additional species have been collected from nearby waters (Table 2). All typically occur in depths greater than those sampled during the Hourglass Cruises.

KEY TO SALENOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Ambulacral plates bigeminate throughout; primary spines with red bands . . . *Salenia goesiana* Lovén
1. Ambulacral plates usually simple, bigeminate near peristome; primary spines not banded 2
2. Spines on periproct enlarged distally (Figure 2i); periproct purple . . *Salenocidaris varispina* A. Agassiz
2. Spines on periproct tapered distally (Figure 2j); periproct whitish . . . *Salenocidaris profundus* (Duncan)

ORDER ARBACIOIDA GREGORY, 1900

Three species belonging to this order have been collected in the Gulf of Mexico and another has been collected from nearby waters (Table 2).

KEY TO ARBACIOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Primary spines confined to oral surface of test; test with papillary structures arranged in longitudinal series, presenting sculptured appearance; small forms, generally less than 10 mm HD 2
1. Primary spines not confined to oral surface of test; no such papillary structures present; larger forms, generally greater than 10 mm HD 3
2. Anal pyramid composed of five valves *Habrocidaris scutata* (A. Agassiz)
2. Anal pyramid composed of four valves *Podocidaris sculpta* A. Agassiz
3. Primary spines two or more times longer than test diameter, bright red, triangular in cross-section; oral spines not tipped with shiny flattened cap; interambulacral areas bright red; secondary spines present *Coelopleurus floridanus* A. Agassiz
3. Primary spines less than one and one-half times longer than test diameter, not bright red, round in cross-section; oral spines tipped with shiny flattened cap; interambulacral areas not bright red; secondary spines absent *Arbacia punctulata* (Lamarck)

Family Arbaciidae Gray, 1855

Arbacia punctulata (Lamarck, 1816)

Figure 9

Echinus punctulatus Lamarck, 1816, p. 47.

Echinocidaris punctulata: A. Agassiz, 1869, p. 257.

Arbacia punctulata: A. Agassiz, 1872, pp. 91, 263, 734, 735, text-figs. 68, 69, pl. 2, fig. 4, pl. 5, figs. 1-18; Rathbun, 1885, p. 612; A. Agassiz and H. L. Clark, 1908, p. 71, pl. 47, figs. 17-19, pl. 48, figs. 1-9; Tortonese, 1933, p. 112; Mortensen, 1935, p. 573, pl. 87, figs. 7-10; Whitten et al., 1950, p. 85; A. H. Clark, 1954, p. 274; Mayr, 1954, p. 10; Hildebrand, 1955, p. 195; Harvey, 1956, pp. 1-298; Sharp and Gray, 1962, p. 309; Kier and Grant, 1965, p. 17, pl. 2, figs. 8, 9, pl. 10, fig. 5; Dawson, 1966, p. 178; Roa, 1967, p. 300; Richmond, 1968, p. 237; Menzel, 1971, p. 86; Chesher, 1972, p. 150; Jolley, 1972, p. 36; Godcharles and Jaap, 1973, p. 51; Burke, 1974, p. 315, fig. 1; Avent et al., 1977, p. 200; Hopkins et al., 1977, p. 35.

Material examined: HOURGLASS STATION A: 1, 4.3 mm; 3 August 1965; trawl; FSBC I 10939. — 6 adults; 30 August 1965; dredge. — 1 adult; 4 October 1965; trawl. — 3, 28.0-29.0 mm; 3 March 1966; trawl. — 4, 36.0-39.0 mm; 3 March 1966; dredge. — 2, 38.0, 42.0 mm; 6 April 1966; trawl. — 2, 10.0, 20.0 mm; 6 April 1966; dredge. — 1, 19.0 mm; 2 May 1966; trawl. — 3, 29.0-43.0 mm; 6 June 1966; dredge. — 1, 28.0 mm; 2 July 1966; dredge. — 1, 34.3 mm; 6 January 1967; dredge. — 1, 28.7 mm; 5 February 1967; dredge. — 1, 4.2 mm; 2 March 1967; dredge. — 1, 35.3 mm; 3 April 1967; dredge; FSBC I 10961. — 1, 25.3 mm; 1 July 1967; dredge; FSBC I 10970. — 3, 2.3-24.4 mm; 1 August 1967; dredge;

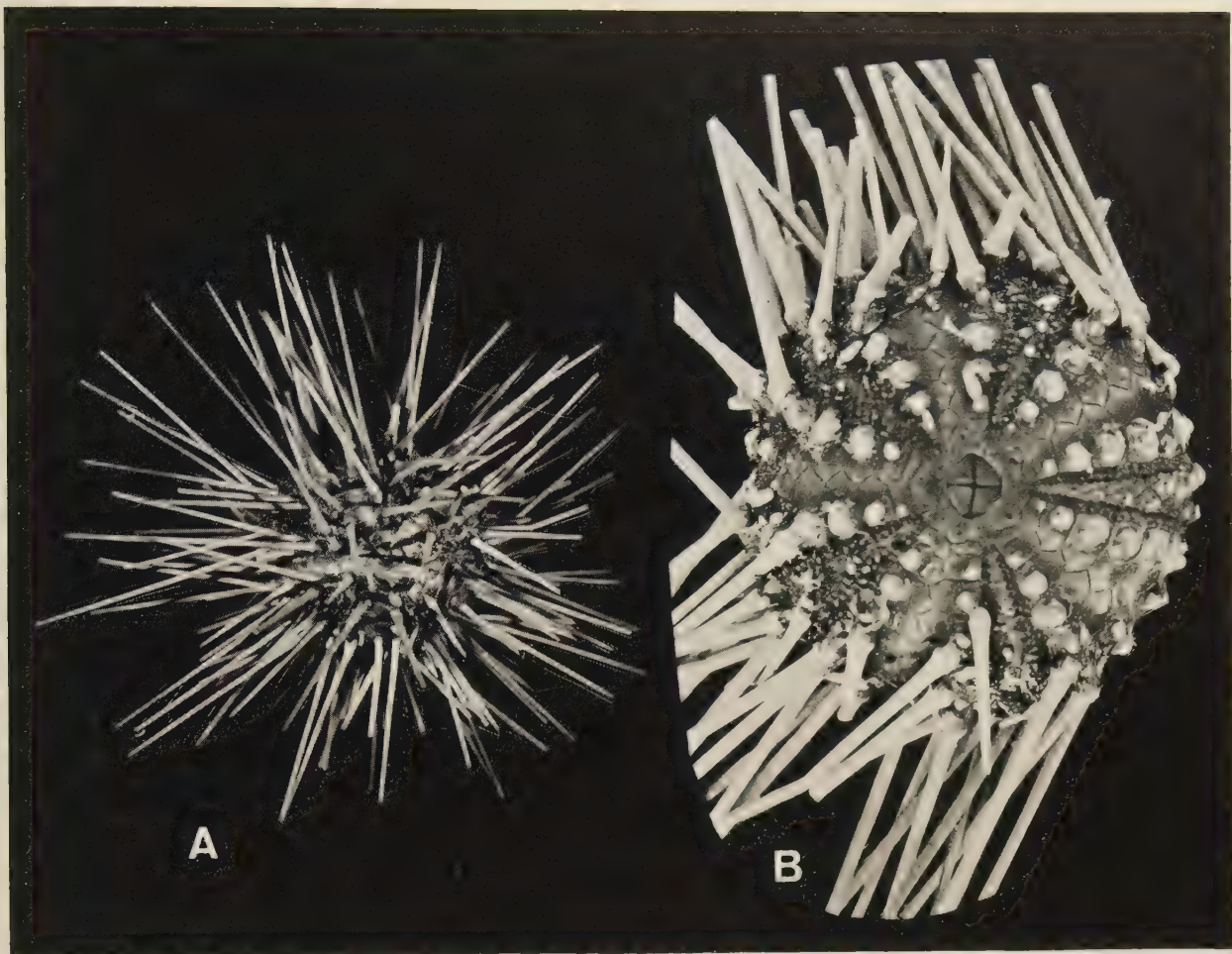


Figure 9. *Arbacia punctulata*, aboral aspects: A, 38 mm HD; Station K, March 1978; FSBC I 18974; B, 29 mm HD; Station C, November 1967; USNME 15004.

FSBC I 10975. — 1, 1.7 mm; 5 October 1967; dredge; FSBC I 10982. — HOURGLASS STATION B: 1 adult; 3 August 1965; trawl. — 2 adults; 30 August 1965; trawl. — 2, 27.0, 48.0 mm; 20 October 1965; trawl. — 1, 35.0 mm; 8 November 1965; dredge. — 1, 10.0 mm; 19 November 1965; dredge. — 1, 39.0 mm; 3 December 1965; trawl. — 1 adult; 3 January 1966; trawl. — 1, 8.0 mm; 3 January 1966; dredge; FSBC I 1543. — 2, 4.0, 9.0 mm; 19 January 1966; trawl. — 2, 7.0, 9.0 mm; 19 January 1966; dredge. — 3, 2.9-24.0 mm; 7 February 1966; trawl. — 10, 4.6-32.2 mm; 7 February 1966; dredge; FSBC I 1906. — 2, 29.0, 37.0 mm; 20 February 1966; trawl. — 2, 8.0, 35.0 mm; 20 February 1966; dredge. — 9, 6.0-11.0 mm; 3 March 1966; trawl. — 4, 7.0-15.0 mm; 3 March 1966; dredge. — 1, 16.0 mm; 26 March 1966; trawl. — 5, 9.0-16.0 mm; 26 March 1966; dredge. — 1, 11.0 mm; 6 April 1966; dredge. — 1, 40.0 mm; 15 April 1966; trawl. — 2, both 9.0 mm; 15 April 1966; dredge. — 5, 11.0-24.0 mm; 2 May 1966; trawl. — 3, 8.0-13.0 mm; 2 May 1966; dredge. — 1, 37.0 mm; 18 May 1966; trawl. — 2, 24.0, 42.0 mm; 18 May 1966; dredge. — 5, 9.0-36.0 mm; 6 June 1966; trawl. — 4, 18.0-27.0 mm; 6 June 1966; dredge. — 4, 10.0-21.0 mm; 17 June 1966; trawl. — 1, 2.1 mm; 17 June 1966; dredge. — 1, 11.0 mm; 10 July 1966; trawl. — 5, 6.0-31.0 mm; 10 July 1966; dredge. — 20, 9.0-32.0 mm; 18 July 1966; trawl. — 1, 25.0 mm; 1 August 1966; trawl. — 4, 5.2-27.0 mm; 1 August 1966; dredge. — 5, 18.0-28.0 mm; 8 September 1966; dredge. — 3, 2.0-7.3 mm; 18 October 1966; dredge; FSBC I 10941. — 2, 15.2, 15.7 mm; 19 November 1966; trawl. — 7, 7.9-32.1 mm; 1 December 1966; trawl; FSBC I 10946. — 2, 21.1, 32.9 mm; 13 December 1966; trawl. —

2, 15.4, 28.0 mm; 13 December 1966; dredge; FSBC I 10948. — 1, 2.2 mm; 6 January 1967; dredge; FSBC I 10949. — 19, 6.5-31.7 mm; 25 January 1967; trawl; FSBC I 10950. — 4, 21.0-31.0 mm; 5 February 1967; trawl; FSBC I 10951. — 1, 16.4 mm; 5 February 1967; dredge. — 2, 3.0, 3.3 mm; 27 February 1967; trawl. — 1, 33.7 mm; 27 February 1967; dredge. — 3, 13.4-27.6 mm; 2 March 1967; trawl. — 1, 37.6 mm; 14 March 1967; trawl; FSBC I 10958. — 3, 2.4-2.8 mm; 14 March 1967; dredge; FSBC I 10959. — 3, 6.0-21.5 mm; 3 April 1967; trawl. — 2, 3.8, 25.8 mm; 3 April 1967; dredge. — 2, 5.0, 20.8 mm; 11 April 1967; trawl. — 1, 14.9 mm; 11 April 1967; dredge. — 1, 7.6 mm; 11 May 1967; dredge. — 4, 1.7-3.8 mm; 20 May 1967; dredge. — 2, 4.3, 38.2 mm; 20 June 1967; trawl. — 1, 4.9 mm; 20 June 1967; dredge. — 2, 5.8, 35.3 mm; 1 July 1967; trawl. — 1, 8.7 mm; 1 July 1967; dredge. — 2, 2.0, 8.1 mm; 11 July 1967; dredge. — 6, 2.2-6.2 mm; 1 August 1967; dredge; FSBC I 10976. — 3, 3.0-12.5 mm; 11 August 1967; dredge; FSBC I 10978. — 12, 1.8-18.1 mm; 31 August 1967; dredge; FSBC I 10979. — 3, 5.8-38.9 mm; 11 September 1967; trawl. — 6, 4.2-33.4 mm; 11 September 1967; dredge; FSBC I 10981. — 2, 14.4, 16.3 mm; 5 October 1967; trawl. — 17, 2.4-18.4 mm; 5 October 1967; dredge; FSBC I 10983. — 4, 3.8-7.7 mm; 25 October 1967; dredge. — 2, 14.1, 24.3 mm; 2 November 1967; trawl. — 74, 1.0-6.8 mm, 1 dead juvenile test; 2 November 1967; dredge; FSBC I 10991. — 5, 2.0-7.5 mm; 20 November 1967; trawl. — 11, 2.0-23.4 mm; 20 November 1967; dredge; FSBC I 10996. — HOURGLASS STATION C: 1 adult; 26 August 1965; dredge. — 2, 4.0, 13.0 mm; 3 January 1966; trawl. — 4, 3.2-5.0 mm; 3 January 1966; dredge. — 1, 23.0 mm; 19 January 1966; dredge. — 2, 2.4, 15.0 mm; 7 February 1966; dredge. — 2, 4.8, 19.0 mm; 20 February 1966; dredge. — 3, 10.0-21.0 mm; 27 March 1966; dredge. — 1, 8.0 mm; 6 April 1966; dredge. — 2, 10.0, 30.0 mm; 16 April 1966; trawl. — 3, 9.0-13.0 mm; 16 April 1966; dredge. — 3, 31.9-36.2 mm; 2 May 1966; trawl. — 1, 9.0 mm; 2 May 1966; dredge. — 2, 11.0, 25.0 mm; 19 May 1966; dredge. — 2, 11.0, 17.0 mm; 6 June 1966; dredge. — 4, 7.0-23.0 mm; 2 July 1966; dredge. — 1, 18.0 mm; 11 July 1966; trawl. — 2, 11.0, 14.0 mm; 11 July 1966; dredge. — 1, 15.0 mm; 1 August 1966; dredge. — 3, 12.8-15.9 mm; 19 November 1966; trawl; FSBC I 10944. — 4, 5.9-17.7 mm; 19 November 1966; dredge; FSBC I 10945. — 1, 24.4 mm; 1 December 1966; trawl. — 15, 2.3-24.6 mm; 1 December 1966; dredge; FSBC I 10947. — 1, 11.0 mm; 13 December 1966; trawl. — 3, 4.1-16.8 mm; 13 December 1966; dredge. — 2, 9.9, 22.7 mm; 6 January 1967; trawl. — 8, 4.3-27.3 mm, 1 dead test, 3.8 mm; 6 January 1966; dredge. — 2, 15.7, 19.3 mm; 5 February 1967; trawl. — 6, 6.0-19.5 mm; 5 February 1967; dredge; FSBC I 10952. — 2, 13.0, 22.5 mm; 27 February 1967; trawl. — 6, 7.2-26.1 mm; 2 March 1967; trawl; FSBC I 10954. — 7, 4.3-21.3 mm; 2 March 1967; dredge. — 4, 10.6-15.7 mm; 3 April 1967; trawl; FSBC I 10962. — 9, 2.8-13.9 mm; 3 April 1967; dredge; FSBC I 10963. — 1, 5.2 mm; 12 April 1967; trawl; FSBC I 11113. — 2, 3.4, 5.2 mm; 11 May 1967; dredge. — 5, 2.2-11.4 mm, 1 dead test, 2.9 mm; 20 May 1967; trawl; FSBC I 10966. — 2, 5.8, 7.6 mm; 20 May 1967; dredge. — 1, 7.2 mm; 2 June 1967; trawl; FSBC I 10967. — 2, 6.2, 12.1 mm, 1 dead test, 4.6 mm; 2 June 1967; dredge; FSBC I 10968. — 1, 6.0 mm; 21 June 1967; dredge. — 4, 7.4-14.2 mm; 1 July 1967; dredge. — 3, 8.4-23.2 mm; 11 July 1967; dredge. — 2, 13.2, 20.6 mm; 1 August 1967; trawl. — 1, 13.8 mm; 11 August 1967; trawl. — 2, 12.2, 14.3 mm; 11 August 1967; dredge. — 5, 1.8-17.9 mm; 31 August 1967; trawl. — 1, 15.7 mm; 11 September 1967; trawl. — 6, 11.8-19.8 mm; 11 September 1967; dredge. — 1, 11.3 mm; 5 October 1967; trawl; FSBC I 10984. — 5, 13.8-29.4 mm; 5 October 1967; dredge; FSBC I 10985. — 1, 16.7 mm; 25 October 1967; trawl; FSBC I 10989. — 2, 8.3, 34.0 mm; 25 October 1967; dredge. — 4, 10.5-29.0 mm; 2 November 1967; trawl. — 5, 2.4-40.1 mm; 21 November 1967; trawl. — 10, 2.4-39.9 mm; 21 November 1967; dredge; FSBC I 6850. — HOURGLASS STATION D: 1 adult; 5 October 1965; trawl. — 1, 2.4 mm; 8 February 1966; trawl. — 1, 4.2 mm; 21 February 1966; trawl. — 1 dead test, 3.6 mm; 21 February 1966; dredge. — 1, 2.6 mm; 27 March 1966; dredge. — 1, 6.0 mm; 16 April 1966; trawl. — 3, 31.0-37.0 mm; 3 May 1966; trawl. — 1, 13.8 mm; 3 July 1966; trawl; FSBC I 3078. — 1, 2.4 mm; 2 August 1966; trawl. — 1, 8.0 mm; 1 September 1966; trawl. — 1, 22.0 mm; 9 October 1966; trawl. — 2, 2.2, 12.8 mm; 19 October 1966; dredge. — 1, 13.2 mm; 9 November 1966; dredge; FSBC I 6804. — 5, 3.4-6.4 mm; 20 November 1966; trawl. — 1, 2.2 mm; 20 November 1966; dredge. — 1, 3.4 mm; 14 December 1966; trawl. — adult fragment; 7 January 1967; dredge. — 1, 22.3 mm; 28 February 1967; trawl. — 1, 3.1 mm; 3 March 1967; dredge; FSBC I 10955. — 1, 1.7 mm; 15 March 1967; dredge; FSBC I 10960. — 1 dead test, 3.2 mm; 4 April 1967; dredge. — 1, 5.7 mm;

12 May 1967; trawl; FSBC I 10964. — 1 dead test, 2.9 mm; 12 May 1967; dredge; FSBC I 10965. — 1, 3.0 mm, 1 dead test, 3.1 mm; 21 May 1967; dredge. — 1, 8.9 mm; 2 July 1967; trawl. — 1, 3.4 mm, 1 dead test, 3.0 mm; 2 July 1967; dredge. — 1, 7.7 mm; 2 August 1967; trawl. — 1, 5.0 mm; 2 August 1967; dredge; FSBC I 6780. — 1, 2.0 mm; 6 October 1967; dredge. — 1, 2.1 mm; 27 October 1967; trawl; FSBC I 10990. — HOURGLASS STATION I: 3 adults; 6 August 1965; trawl. — 3 adults; 3 September 1965; trawl. — 1 adult; 3 September 1965; dredge. — 4 adults; 12 October 1965; trawl. — 2, 38.0, 40.0 mm; 12 October 1965; dredge. — 9, 23.0-44.0 mm; 12 November 1965; trawl. — 16, 28.0-42.0 mm; 12 November 1965; dredge. — 13, 21.0-35.0 mm; 6 December 1965; trawl. — 14, 31.0-39.0 mm; 6 December 1965; dredge. — 2, 36.0, 36.2 mm; 13 January 1966; trawl; FSBC I 1626. — 14, 32.0-43.0 mm; 14 February 1966; dredge. — 36, 34.0-42.0 mm; 9 March 1966; trawl. — 2, 38.0, 39.0 mm; 9 March 1966; dredge. — 14, 29.0-38.0 mm; 21 March 1966; trawl. — 34, 26.0-41.0 mm; 21 March 1966; dredge. — 12, 34.0-48.0 mm; 11 April 1966; trawl. — 53, 30.0-42.0 mm; 11 April 1966; dredge. — 30, 32.0-38.0 mm; 11 May 1966; trawl. — 21, 14.0-40.0 mm; 11 May 1966; dredge. — 5, 28.0-39.0 mm; 12 June 1966; trawl. — 6, 22.0-37.0 mm; 12 June 1966; dredge. — 6, 23.0-39.0 mm; 5 July 1966; trawl. — 9, 32.0-40.0 mm; 5 July 1966; dredge. — 1, 8.0 mm; 5 August 1966; trawl. — 5, 33.0-43.0 mm; 5 August 1966; dredge. — 10, 2.2-4.2 mm; 15 May 1967; dredge. — 3, 5.1-6.5 mm; 6 June 1967; dredge. — 2, 9.2, 9.5 mm, 1 dead test, 8.9 mm; 7 July 1967; dredge. — 5, 9.8-16.4 mm; 7 August 1967; dredge. — 1, 17.6 mm; 4 September 1967; trawl. — 7, 11.4-22.9 mm; 4 September 1967; dredge. — 1, 23.6 mm; 11 October 1967; trawl. — 7, 10.0-22.3 mm; 11 October 1967; dredge; FSBC I 10986. — 1, 16.1 mm; 14 November 1967; trawl; FSBC I 10992. — 6, 24.1-38.7 mm; 14 November 1967; dredge; FSBC I 10993. — HOURGLASS STATION J: 2, 30.0, 38.0 mm; 13 January 1966; trawl. — 1, 2.3 mm; 13 January 1966; dredge. — 2, 18.0, 30.0 mm; 14 February 1966; trawl. — 1, 2.4 mm; 14 February 1966; dredge. — 1, 26.0 mm; 21 March 1966; trawl. — 1, 35.0 mm; 21 March 1966; dredge. — 1, 36.0 mm; 11 April 1966; trawl. — 3, 10.0-34.0 mm; 11 May 1966; trawl. — 1, 11.0 mm; 11 May 1966; dredge. — 3, 5.0-45.0 mm; 12 June 1966; dredge. — 2, 12.0, 20.0 mm; 21 July 1966; trawl. — 1, 29.0 mm; 12 October 1966; trawl. — 5, 7.0-29.7 mm; 12 November 1966; trawl; FSBC I 10942. — 2, 19.3, 22.1 mm; 12 November 1966; dredge. — 2, 17.0, 21.2 mm; 6 December 1966; dredge. — 3, 18.4-40.1 mm; 12 January 1967; trawl. — 1, 1.9 mm; 15 February 1967; trawl. — 2, 1.4, 1.9 mm; 15 February 1967; dredge. — 4, 3.0-35.7 mm; 8 March 1967; dredge; FSBC I 10956. — 7, 2.3-24.9 mm; 7 April 1967; dredge. — 3, 3.2-36.7 mm; 15 May 1967; dredge. — 1, 23.2 mm; 6 June 1967; dredge. — 6, 8.1-22.0 mm; 5 July 1967; dredge; FSBC I 10971. — 1, 28.6 mm; 7 August 1967; trawl. — 4, 16.5-23.7 mm; 11 October 1967; trawl; FSBC I 10987. — 16, 1.6-37.7 mm; 14 November 1967; trawl; FSBC I 10994. — 446, 1.0-24.7 mm; 14 November 1967; dredge; FSBC I 10995. — HOURGLASS STATION K: 1, 3.0 mm; 13 January 1966; trawl. — 2, 9.0, 12.0 mm; 5 July 1966; dredge. — 2, 10.0, 16.0 mm; 5 August 1966; trawl. — 1, 5.2 mm; 12 October 1966; dredge. — 1, 9.0 mm; 12 November 1966; trawl. — 10 dead tests, 1.7-6.2 mm; 6 December 1966; dredge. — 2, 8.4, 13.6 mm; 30-31 January 1967; trawl. — 3, 9.9-17.4 mm; 15 February 1967; trawl. — 1, 11.9 mm; 8 March 1967; trawl. — 2, 9.2, 13.6 mm; 8 March 1967; dredge; FSBC I 10957. — 7, 6.8-11.9 mm; 7 April 1967; dredge. — 1, 12.4 mm; 6 June 1967; trawl. — 4, 8.5-25.6 mm; 6 June 1967; dredge; FSBC I 10969. — 2, 9.2, 10.2 mm; 5 July 1967; trawl; FSBC I 10972. — 3, 4.7-5.7, 1 dead test, 4.5 mm; 5 July 1967; dredge. — 2, 3.7 mm, adult fragment; 4 September 1967; trawl. — 2, 2.1, 8.1 mm; 4 September 1967; dredge. — 1, 17.7 mm; 11 October 1967; trawl; FSBC I 10988. — 3, 3.1-7.8 mm; 11 October 1967; dredge. — 3, 0.7-11.0 mm; 14 November 1967; dredge. — HOURGLASS STATION L: 2, 11.0, 18.0 mm; 6 August 1966; dredge. — 4, 2.0-3.0 mm, 15 dead juvenile tests; 5 September 1966; dredge; FSBC I 4102. — 1, 2.7 mm; 19 October 1966; trawl. — 10 dead tests, 1.0-4.2 mm; 13 October 1966; dredge. — 1, 12.5 mm, 1 dead test, 2.0 mm; 13 November 1966; dredge; FSBC I 10943. — 1, 2.0 mm; 7 December 1966; dredge. — 1 dead test, 3.0 mm; 13 January 1967; trawl. — 1, 5.1 mm; 16 February 1967; trawl; FSBC I 10953. — 1, 1.1 mm; 9 March 1967; trawl. — 1, 1.4 mm; 8 April 1967; dredge. — 3, 2.3-3.6 mm; 16 May 1967; dredge. — 2, 2.2, 4.5 mm; 7 June 1967; trawl. — 1, 5.3 mm, 3 dead tests, 1.6-3.2 mm; 7 June 1967; dredge. — 1, 7.4 mm; 6 July 1967; trawl; FSBC I 10973. — 1, 10.1 mm; 8 August 1967; trawl. — 1, 6.0 mm, 3 dead tests, 1.7-2.2 mm; 8 August 1967; dredge. — 1, 9.3 mm; 5 September 1967; trawl; FSBC I 10980. — 3 dead tests, 1.6-2.4 mm; 5 September 1967; dredge. — 1 dead

test, 3.2 mm; 12 October 1967; dredge. — 2, 0.7, 1.2 mm; 15 November 1967; trawl. — 1, 1.0 mm; 15 November 1967; dredge. — HOURGLASS STATION M: 1, 1.0 mm; 14 January 1966; dredge; FSBC I 10940. — 1, 33.0 mm; 13 June 1966; trawl. — 27 dead tests, 2.0-3.8 mm; 5 September 1966; dredge. — 1, 3.3 mm; 16 February 1967; trawl. — 1 dead test, 2.8 mm; 6 July 1967; trawl; FSBC I 10974. — 2 dead tests, 2.2, 2.7 mm; 8 August 1967; trawl. — 5 dead tests, 1.9-3.7 mm; 5 September 1967; dredge. — 1 dead test, 1.5 mm; 15 November 1967; dredge.

Diagnosis: Tubercles imperforate; anal pyramid present; ambulacral plates trigeminate; secondary spines absent; oral primary spines tipped with shiny, flattened caps.

Distribution: This species occurs from Cape Cod, Massachusetts, southward to the Bahama Islands, northern Cuba and the Yucatan Peninsula and from Texas to Florida in the Gulf of Mexico. It also occurs off the coast of South America from Panama to French Guiana and in the Lesser Antilles as far north as Barbados. The North and South American populations are believed to be separated geographically and should be examined in more detail by future workers. The species occurs from 0 to 225 m, but is most common in less than 50 m.

Bottom type: Harvey (1956) reported that *A. punctulata* lives in aggregations on rocky or shelly bottoms. Sharp and Gray (1962) stated it is commonly found on sandy shell bottoms, pilings and rock jetties off Beaufort, North Carolina. In this study, it occurred most frequently on quartz sand and crushed shell, often in association with limestone outcroppings at nearshore stations (Table 7).

TABLE 7. NUMBERS OF *ARBACIA PUNCTULATA* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Arbacia punctulata																																	
Sta	1965					1966																	1967										Tot
	A	S	O	N	D	J	F	M	A	M	J	J	Jsp	A	S	O	N	D	J	Jsp	F	M	A	M	J	J	A	S	O	N			
A	1	6	1					7	4	1	3	1								1		1	1	1			1	3		1		33	
B ₁	1	2		1	1	2	13	13	1	8	9		20	5				7	1	18	5	3	5	1		3	6	12	19	76	232		
B ₂			2	1		4	4	6	3	3	5	6			5	3	2	4			3	4	3	4	3	2	3	9	4	16	99		
C ₁						5	2		1	4	2	4		1				16	10		8	13	13	2	3	4	2	5	6	4	105		
C ₂	1					1	2	3	5	2		3		2			7	4			2		1	7	1	3	3	7	3	15	72		
D ₁			1				1				3	1		1	1	1	1					1		1		2	1		1		16		
D ₂							1	1	1								2	6	1			1	1		1				1		16		
E																											1				1		
I	3	4	6	25	27	2	14	48	65	51	11	15		6									10	3	2	5	8	8	7	320			
J						3	3	2	1	4	3		2			1	7	2	3		3	4	7	3	1	6	1		4	60	120		
K						1							2			1	1			2	3	3	7		5	5		4	4	3	43		
L														2	4	1	1	1			1	1	1	3	3	1	2	1		3	25		
M						1					1										1										3		
TOT	6	12	10	27	28	19	40	80	81	76	34	32	22	19	10	9	25	35	15	20	28	31	38	32	19	29	27	46	51	184	1085		

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Diet: The species is primarily an herbivore, but has been known to eat coral polyps, sponges, mussels, sand dollars and other *Arbacia* in aquaria (Harvey, 1956).

Growth and reproduction: *Arbacia punctulata* spawns at Woods Hole, Massachusetts, from the middle of June to the middle of August; at Beaufort, North Carolina, specimens are ready to spawn in May and a few as early as January, but gametes are ripe throughout the year at Alligator Harbor, Florida, in the Gulf (Harvey, 1956). Size frequency data from this study (Figure 10) indicate that spawning occurs all year in the eastern

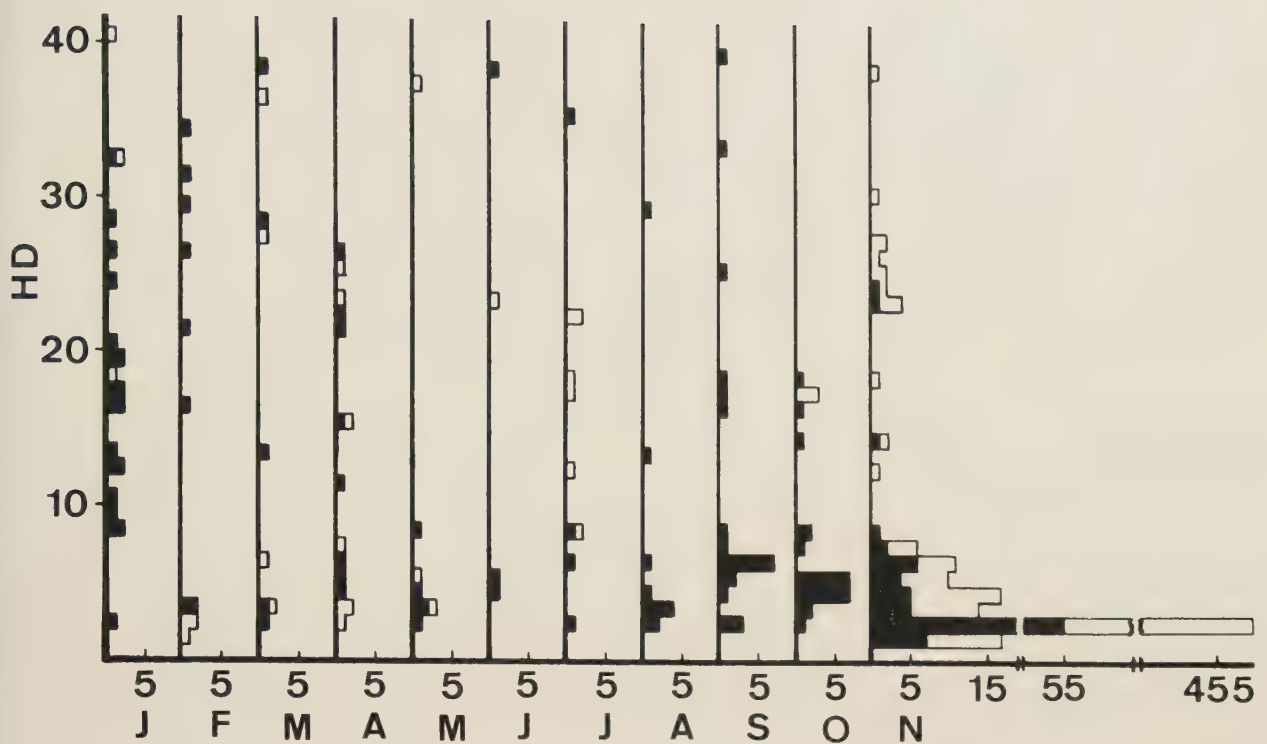


Figure 10. Size frequency plots for *A. punctulata*, Stations B (closed blocks) and J (open blocks), January-November 1967. HD in mm.

Gulf, with a major peak in the fall. This continuous recruitment makes year class separations by size alone difficult. A single settlement of *A. punctulata* occurred in April 1967 at Station I; growth of this population was followed for seven months (Figure 11). Since relative growth in other echinoids is generally reduced after the first year's growth, it is probable that growth begins to slow down around 25 mm HD. Harvey (1956) reported that mean HD of ten specimens kept in aquaria at Woods Hole increased from 22.4 to 23.5 mm HD in three months from June to September. She then estimated that a medium sized specimen (presumably about 23 mm HD) grows approximately 3 mm each year. A single juvenile followed in the laboratory increased from 3.6 mm HD in July to 5.2 mm HD in September, a growth of 1.6 mm in two months. These values are much lower than the 3.3 mm per month increase in HD obtained in this study for specimens in nature. Comparisons of field and laboratory studies are difficult, and differences in water temperature between Woods Hole and Florida may account for this discrepancy.

Length of larval life of *A. punctulata* is about two months at Woods Hole (Harvey, 1956), but length of larval life in Florida waters is unknown. At Woods Hole, several specimens had ripe gametes at 10 mm HD, and one male had functional sperm at 6 mm HD (Harvey, 1956). If growth data shown in Figure 11 are correct, *A. punctulata* metamorphosing in late winter or early spring could themselves spawn by the following fall, thereby accounting for the large settlements at Stations B and J in November 1967 (Figure 11).

Genital pores appear at smaller sizes with increasing depth in the eastern Gulf (Figure 12). Specimens along the southern transect generally develop genital pores at smaller sizes than do those along the northern transect. The general decrease in size at appearance of genital pores with increasing depth could be a factor of decreasing bottom temperatures. However, there are very little differences in bottom temperatures between comparable depths along the northern and southern transects, probably not enough to account for apparent developmental differences (Figure 12).

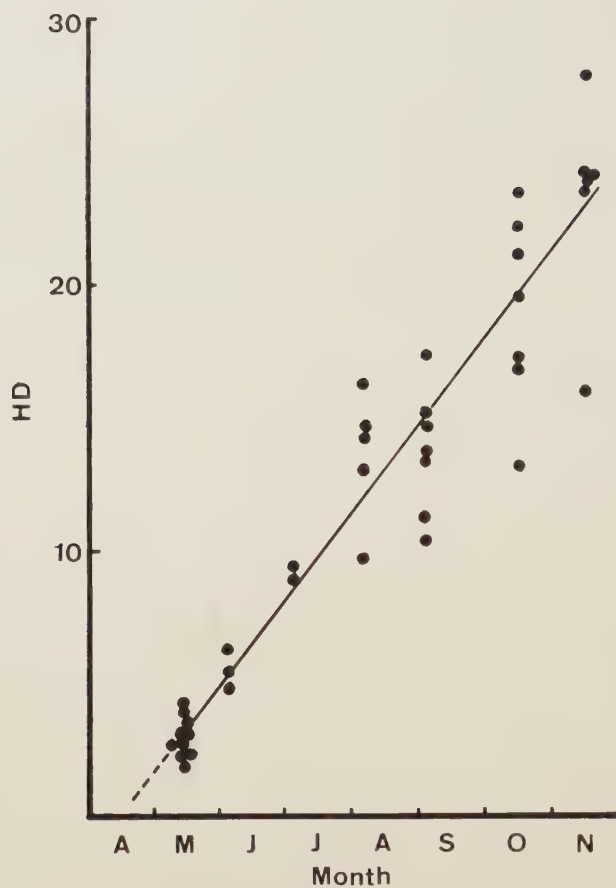


Figure 11. Early growth of *A. punctulata*, April-November 1967, Station I. HD in mm. $y = 3.29x - 1.9$, where $y = \text{HD}(\text{mm})$, $x =$ months after metamorphosis, $r = 0.95$ and $s_{y.x} = 2.52$.

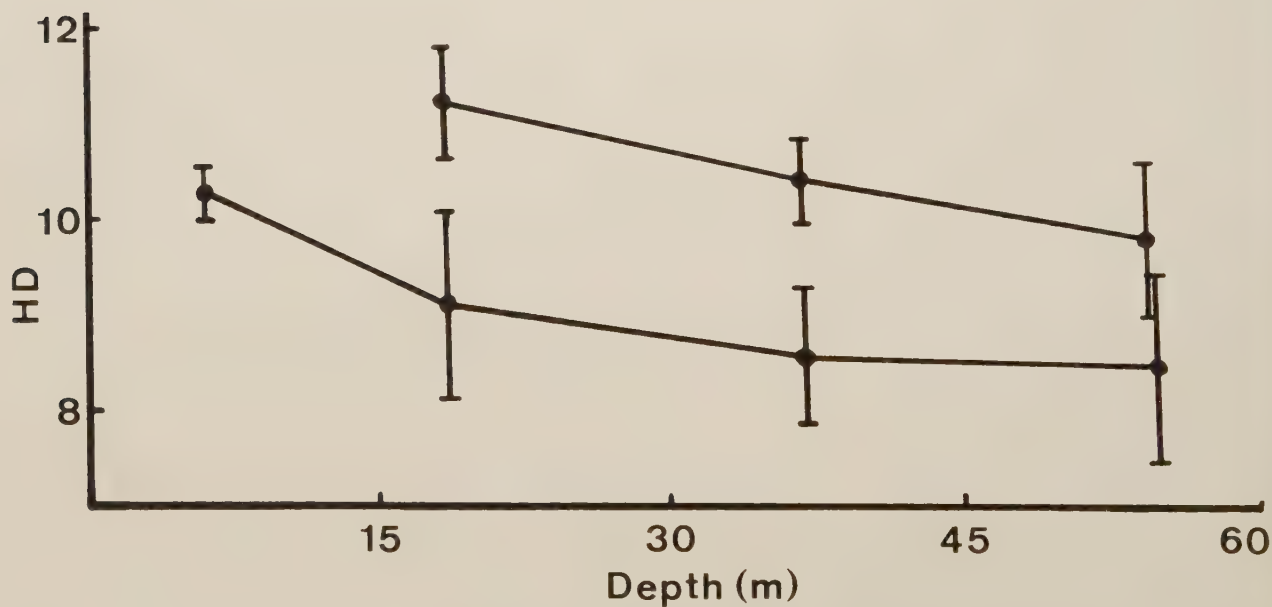


Figure 12. Mean HD (mm) for appearance of genital pores as function of depth (m) in *A. punctulata*. Brackets indicate range. Upper line represents specimens from northern transect off St. Petersburg; lower line represents specimens from southern transect off Ft. Myers.

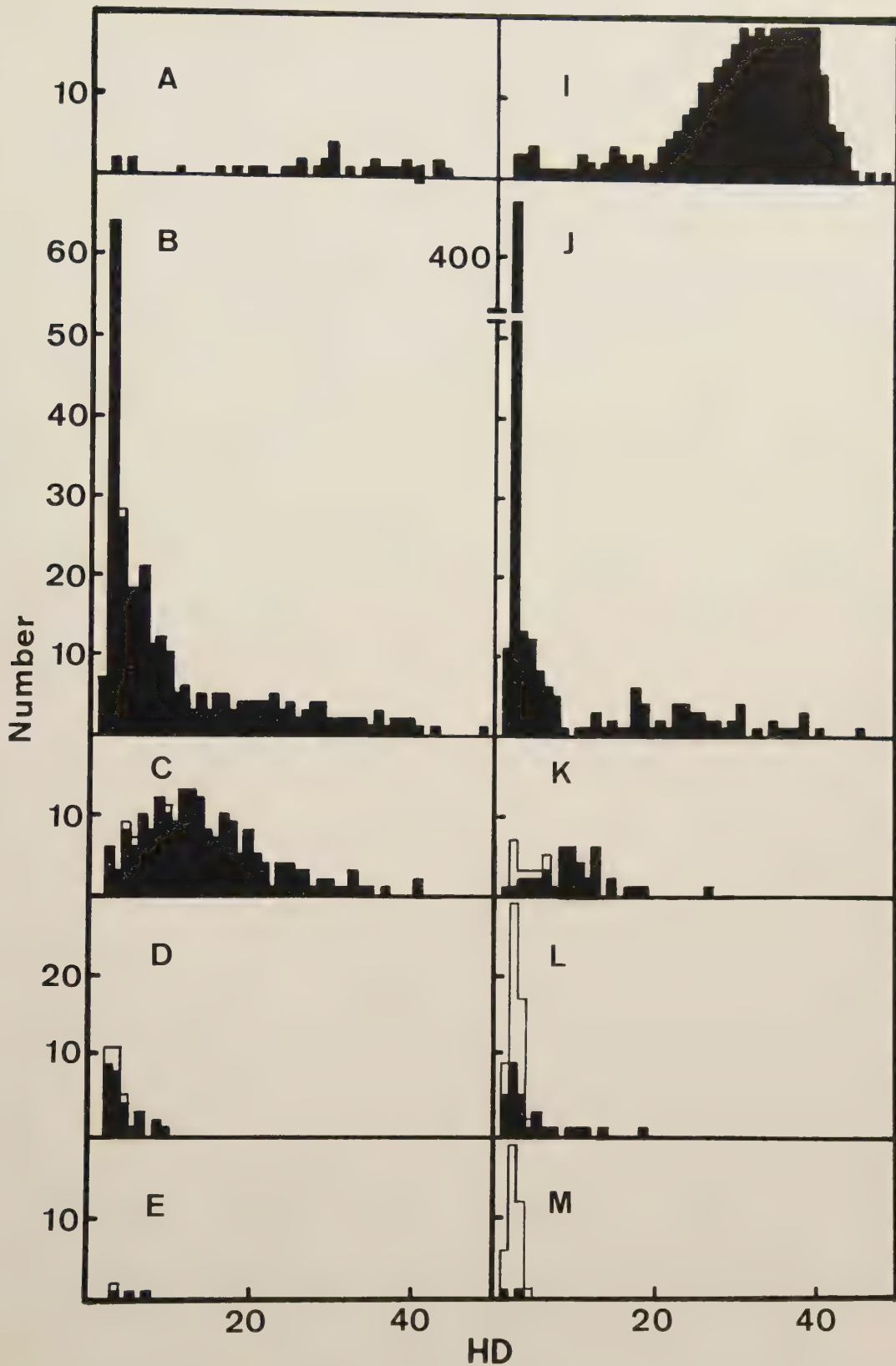


Figure 13. Size frequency plots for *A. punctulata* at each station for duration of study. Closed blocks represent specimens collected living; open blocks represent dead tests. HD in mm. Stations B, C and D sampled twice monthly; remaining stations sampled monthly.

Population dynamics: Figure 13 shows size frequency plots of *A. punctulata* at each station for the duration of the study. Stations B, C and D were sampled twice monthly, and the rest were sampled monthly. It is apparent from Figure 13 that Stations A, D, E, K, L and M have small populations of *A. punctulata*. The large number of juvenile dead tests at Stations K, L and M indicate that larvae settle at offshore stations, but few juveniles survive. The offshore populations at Stations D, E, L and M are believed to be small due to lack of preferred rock or shell substrate. In August 1965, the population at Station I consisted of individuals all about 25 mm HD that probably settled the preceding spring. No recruitment occurred in 1966, but the 1965 year class continued to grow. In the following spring, additional recruitment and growth of a 1967 year class was noted. Therefore, the individuals from 25 to 45 mm HD represent the 1965 year class, and the individuals from 2 to 25 mm HD represent the 1967 year class. Station C had fewer specimens less than 10 mm HD than would otherwise be expected. This is probably not a result of net selection, since net selection did not seem to be a factor at other stations for specimens greater than 3 mm HD. Station J had a fairly small population of *A. punctulata*, but 443 recently metamorphosed individuals were collected in one dredge haul during the last month of the study. A fairly large population occurred at Station B.

According to Ricker (1958), the instantaneous rate of total mortality (i) is equal to the slope of the linear regression line when the natural log of the number of individuals in a population is plotted as a function of age. He also stated that annual mortality (a) is given by the formula $a = 1 - e^{-i}$, where e is 2.718. If the natural log of the number of individuals in a population is plotted as a function of size, mortality can be expressed in terms of size instead of time. Since the relationship between age and size is not known beyond eight months for *A. punctulata*, mortalities can be given in terms of percent mortality per 1 mm increase in HD. Figure 14 shows the natural log of the number of individuals of *A. punctulata* at Station B as a function

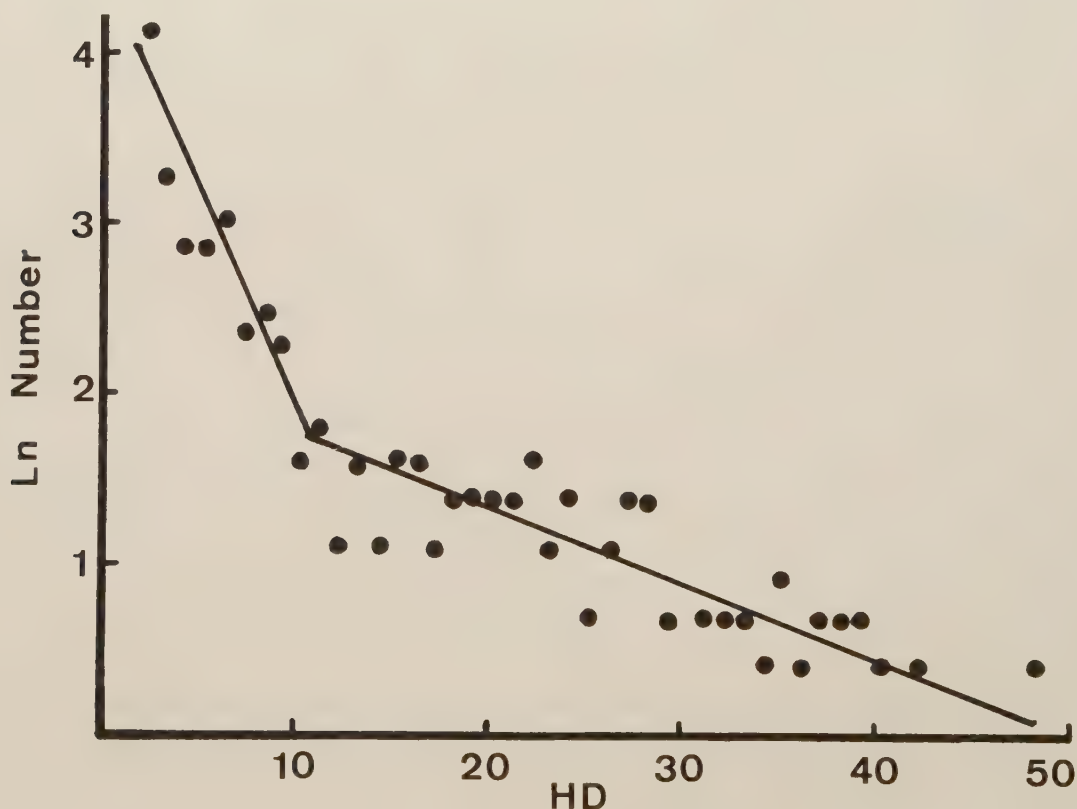


Figure 14. Natural logarithm of number of *A. punctulata* collected at Station B as function of HD (mm). Specimens from 3 to 11 mm have mortality of 21 percent per mm increase in HD; specimens 11 to 49 mm have 4 percent mortality. $N = 342$.

of size. The slope (i) from 3 to 11 mm HD is -0.241 , therefore mortality per 1 mm (a_{mm}) can be calculated from the formula $a_{mm} = 1 - e^{-0.241} = 0.21$, or 21 percent. Mortality drops sharply to 4 percent per 1 mm increase in HD in specimens 11 to 49 mm HD. The greatly reduced mortality occurring at about 11 mm HD coincides with attainment of sexual maturity. The maximum theoretical size of *A. punctulata* can be determined by extrapolating the line to the x-intercept, resulting in a maximum projected size of 50 mm HD.

Gear selectivity: The dredge and trynet collected 816 and 75 juveniles, respectively. However, 531 adults were collected by trynet, but only 378 were collected by dredge.

Morphometric and meristic relationships: Six measurements and four counts were taken on 50 specimens ranging from 4.9 to 40.1 mm HD. Linear regression data for various characters as a function of HD are presented in Table 8.

TABLE 8. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS
AS A FUNCTION OF HD IN *A. PUNCTULATA**.

Character	Regression Equation	$s_{y.x}$	r
TH	$y = 0.56x - 1.37$	1.05	0.98
AS	$y = 0.23x + 1.34$	0.37	0.99
PP	$y = 0.14x + 0.38$	0.28	0.98
IA	$y = 0.21x + 5.57$	0.62	0.96
TUB	$y = 0.60x + 1.50$	2.01	0.95
AMB	$y = 0.38x + 5.99$	0.75	0.98
PS	$y = 0.53x + 1.09$	0.64	0.99
SL	$y = 0.94x + 5.86$	4.61	0.89

*All characters (ordinates) plotted as function of HD (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 50.

Coelopleurus floridanus A. Agassiz, 1872

Figure 15

Coelopleurus floridanus A. Agassiz, 1872, pp. 102, 267, pl. 2c, figs. 14, 15; 1883, p. 23, pls. 7, 8; Rathbun, 1885, p. 612; 1886, p. 265; A. Agassiz and H. L. Clark, 1908, p. 88, pl. 44, figs. 1, 2, pl. 49, figs. 31-33, pl. 53, fig. 11; H. L. Clark, 1918, p. 23; 1922, p. 110; Jackson, 1927, p. 484, text-fig. 43; Mortensen, 1935, p. 612, pl. 68, figs. 5-7, pl. 88, figs. 17, 18, 31-34; A. H. Clark, 1954, p. 374; Lewis, 1961, p. 53; 1963, p. 361.

Material examined: HOURGLASS STATION M: 1, 18.5 mm; 13 January 1967; trawl; FSBC I 4842.

Diagnosis: Test low, subpentagonal in outline; ambulacral plates compound, trigeminate, with primary tubercles in a regular series; interambulacral plates bright red, naked apically, tuberculate adorally; anal pyramid present; primary spines two or more times longer than HD, bright red, triangular in cross-section.

Distribution: *Coelopleurus floridanus* occurs from Cape Cod, Massachusetts southward through the Greater and Lesser Antilles, and from the Florida west coast and Yucatan Peninsula southward along the Central and South American coasts to Surinam. The Hourglass specimen represents a northward range extension

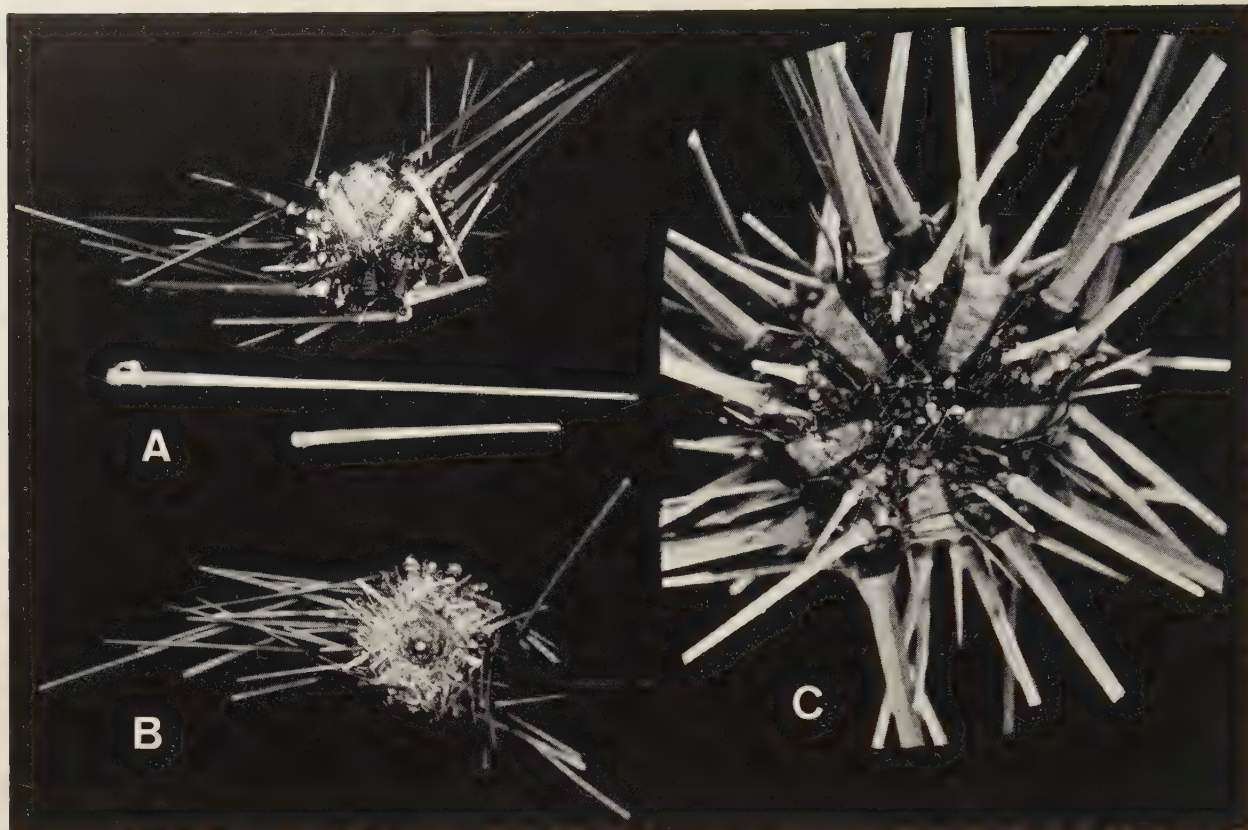


Figure 15. *Coelopleurus floridanus*: A, aboral aspect, 20 mm HD; Station M, January 1967; FSBC I 4842; B, oral aspect, same; C, aboral aspect, 11 mm HD; off Palm Beach, Florida east coast, 183 m; USNM E14272.

in the Gulf and a new shallow limit for the species. It occurs from 73 to 530 m, but is most common from 100 to 300 m.

Bottom type: The specimen was found on an algal sand (*Lithothamnion* spp.) bottom.

Diet: Reported gut contents of five specimens from Barbados include spicules of a telestid octocoral, sand grains, calcareous worm tubes and bryozoan skeletons (Lewis, 1963).

ORDER TEMNOPLEUROIDA MORTENSEN, 1942

Five species and an additional subspecies belonging to this order have been collected in the Gulf of Mexico, and another two species have been recorded from nearby waters (Table 2).

KEY TO TEMNOPLEUROIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Small forms, rarely exceeding 13 mm HD; test sculptured; oculars all broadly exsert 2
1. Large forms, sometimes reaching 85 mm HD; test not sculptured; oculars I and V usually insert in adults 3

2. Test high, generally greater than 50 per cent HD; periproct with single, large, round, shiny suranal plate (exceptionally large specimens greater than 10 mm HD may have a few small accessory plates) *Genocidaris maculata* A. Agassiz
2. Test low, generally less than 50 per cent HD; periproct with large triangular plate, several smaller periproctal plates *Trigonocidaris albida* A. Agassiz
3. Ambulacral pores arranged in three vertical series; primary tubercle present on every third or fourth ambulacral plate; peristome naked except for buccal plates *Tripneustes ventricosus* (Lamarck)
3. Ambulacral pores arranged in arcs of three; primary tubercle present on every ambulacral plate; peristome heavily plated 4
4. Secondary tuberculation scattered irregularly over test, leaving no naked areas in aboral portions of ambulacra and interambulacra 5
4. Secondary tuberculation poorly developed, leaving naked median areas in aboral portions of ambulacra and interambulacra 6
5. Spicules of globiferous pedicellariae dumbbell-shaped (Figure 2k); aboral side of test with red marking *Lytechinus callipeplus* H. L. Clark
5. Spicules of globiferous pedicellariae C-shaped (Figure 2l); test whitish, with some light green adapically *Lytechinus euerces* H. L. Clark
6. Primary IA spines from above ambitus with less than 16 wedges in cross-section; pedicellariae purple *Lytechinus williamsi* Chesher
6. Primary IA spines from above ambitus with more than 16 wedges in cross-section; pedicellariae not purple, generally lighter colored 7
7. Test green, mottled with white *Lytechinus variegatus variegatus* (Lamarck)
7. Test reddish *Lytechinus variegatus carolinus* A. Agassiz

Family Temnopleuridae A. Agassiz, 1869

Genocidaris maculata A. Agassiz, 1869

Figure 16

Genocidaris maculata A. Agassiz, 1869, p. 262; H. L. Clark, 1912, p. 297; 1918, p. 32; 1921, p. 114; Mortensen, 1943, p. 358, pl. 18, figs. 37-47; A. H. Clark, 1954, p. 374; Lewis, 1963, p. 361; Chesher, 1966, p. 218.

Temnechinus maculatus: A. Agassiz, 1872, pp. 165, 286, pl. 8, figs. 1-18; 1883, p. 38; Rathbun, 1885, p. 613.

Material examined: HOURGLASS STATION C: 1, 6.6 mm; 6 November 1966; trawl; FSBC I 11076. — 1 dead test, 5.1 mm; 19 November 1966; dredge; FSBC I 11079. — 1, 6.5 mm; 13 December 1966; dredge. — 3, 4.1-7.6 mm; 6 January 1967; dredge. — 1, 5.3 mm; 20 January 1967; dredge. — 1, 5.7 mm; 5 February 1967; dredge. — 1, 4.9 mm; 2 March 1967; dredge. — 1, 7.6 mm; 3 April 1967; trawl; FSBC I 11082. — 1 dead test, 4.3 mm; 11 May 1967; dredge. — 1 dead test, 3.4 mm; 20 May 1967; dredge. — 2, 3.0, 3.5 mm, 3 dead tests, 2.4-3.4 mm; 2 June 1967; dredge. — 2, 2.8, 3.4 mm, 1 dead test, 3.0 mm; 1 July 1967; dredge. — 1, 3.2 mm; 11 August 1967; dredge; FSBC I 11086. — 3, 3.9-4.5 mm, 1 dead test, 2.2 mm; 31 August 1967; trawl. — 3, 6.1-6.3 mm, 1 dead test, 5.6 mm; 11 September 1967; dredge. — 1, 6.5 mm; 5 October

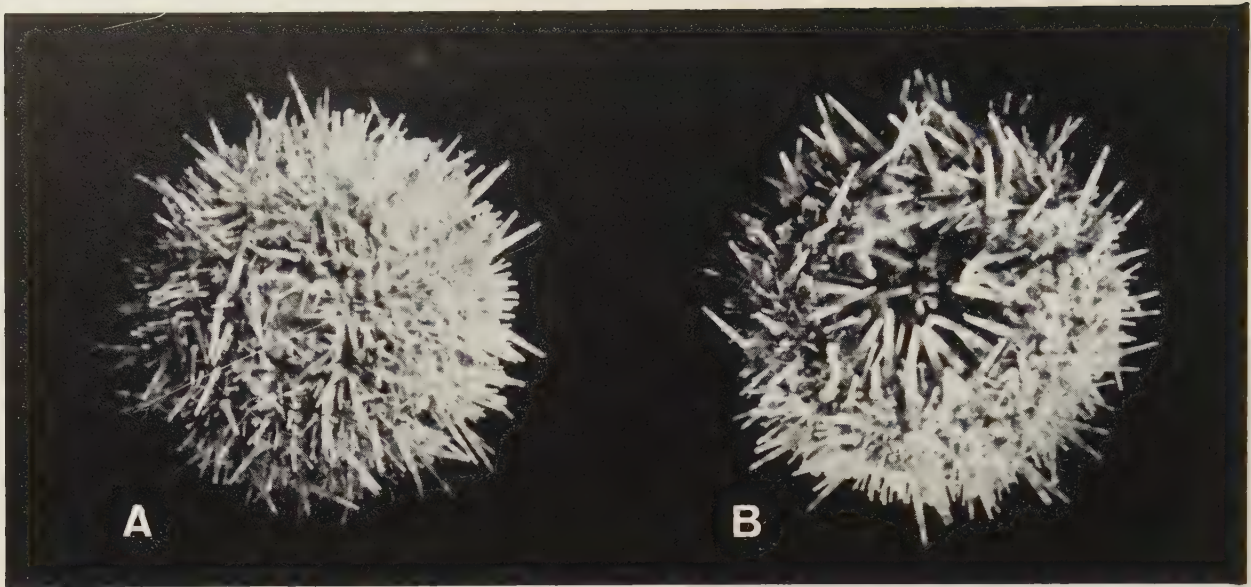


Figure 16. *Genocidaris maculata*: A, aboral aspect, 9 mm HD; Station E, October 1967; FSBC I 6774; B, oral aspect, same specimen.

1967; dredge. — 1, 3.1 mm; 2 November 1967; dredge. — 1, 5.4 mm; 21 November 1967; trawl; FSBC I 11091. — HOURGLASS STATION D: 1, 3.6 mm; 9 November 1965; trawl. — 1 dead test, 2.7 mm; 3 May 1966; dredge. — 7, 2.2-3.0 mm, 5 dead tests, 2.4-4.1 mm; 11 July 1966; trawl; FSBC I 4468. — 1 dead test, 3.7 mm; 11 July 1966; dredge. — 1, 3.8 mm; 2 August 1966; trawl. — 15, 1.9-5.0 mm, 11 dead tests, 2.1-3.1 mm; 2 August 1966; dredge; FSBC I 4470. — 3, 2.1-3.4 mm, 2 dead tests, 2.7, 5.7 mm; 11 August 1966; dredge; FSBC I 4473. — 6, 3.3-5.6 mm, 2 dead tests, 2.9, 4.3 mm; 9 September 1966; trawl; FSBC I 4474. — 4, 3.0-5.0 mm; 9 September 1966; dredge. — 33, 2.3-8.4 mm; 9 October 1966; trawl; FSBC I 4563. — 11, 2.4-7.0 mm; 9 October 1966; dredge; FSBC I 11074. — 3, 3.5-4.0 mm; 19 October 1966; trawl. — 1, 4.5 mm; 19 October 1966; dredge. — 11, 2.7-5.8 mm, 5 dead tests, 3.0-5.2 mm; 9 November 1966; dredge; FSBC I 11077. — 2 dead tests, 2.9, 3.4 mm; 20 November 1966; trawl. — 5, 3.2-4.4 mm, 1 dead test, 4.3 mm; 20 November 1966; dredge. — 2 dead tests, 3.1, 3.7 mm; 2 December 1966; trawl. — 1, 2.2 mm, 1 dead test, 4.1 mm; 14 December 1966; dredge. — 1 dead test, 4.9 mm; 7 January 1967; trawl. — 1 dead test, 3.0 mm; 26 January 1967; trawl. — 1, 3.9 mm, 1 dead test, 3.5 mm; 6 February 1967; dredge. — 1, 4.6 mm; 28 February 1967; trawl. — 1, 5.7 mm, 6 dead tests, 1.8-4.4 mm; 28 February 1967; dredge. — 3, 4.5-5.2 mm, 4 dead tests, 1.5-4.2 mm; 3 March 1967; dredge. — 2 dead tests, 2.2, 2.4 mm; 15 March 1967; dredge. — 2, 8.2, 8.4 mm; 4 April 1967; trawl; FSBC I 11083. — 1, 9.1 mm, 3 dead tests, 2.9-3.9 mm; 4 April 1967; dredge; FSBC I 6777. — 1 dead test, 4.3 mm; 12 April 1967; trawl. — 1, 5.4 mm, 1 dead test, 3.0 mm; 12 May 1967; trawl. — 2, 1.9, 2.4 mm, 24 dead tests, 1.7-4.8 mm; 12 May 1967; dredge. — 12, 1.4-5.1 mm, 37 dead tests, 1.9-6.0 mm; 21 May 1967; dredge. — 1 dead test, 2.9 mm; 3 June 1967; trawl. — 1 dead test, 4.2 mm; 3 June 1967; dredge. — 5 dead tests, 2.8-3.6 mm; 21 June 1967; dredge. — 5, 2.3-4.8 mm, 5 dead tests, 3.3-4.7 mm; 2 July 1967; dredge. — 2, 3.0, 3.1 mm, 7 dead tests, 2.9-4.3 mm; 12 July 1967; dredge. — 4 dead tests, 2.2-4.2 mm; 2 August 1967; trawl. — 3 dead tests, 3.0-6.3 mm; 2 August 1967; dredge. — 1, broken; 25 August 1967; trawl. — 14, 2.6-5.2 mm, 2 dead tests, 2.6, 3.1 mm; 1 September 1967; trawl. — 8, 2.3-4.2 mm, 7 dead tests, 2.8-4.8 mm; 1 September 1967; dredge. — 3, 2.8-5.0 mm; 12 September 1967; dredge. — 5, 2.1-5.5 mm, 9 dead tests, 1.4-4.0 mm; 6 October 1967; trawl. — 3, 4.2-7.5 mm, 5 dead tests, 3.0-4.2 mm; 6 October 1967; dredge; FSBC I 11089. — 1 dead test, 5.9 mm; 27 October 1967; trawl. — 1, 3.4 mm; 27 October 1967; dredge. — 2, 6.3, 7.0 mm, 2 dead tests, both 4.6 mm; 3 November 1967; trawl. — 1, 7.4 mm, 1 dead test, 3.7 mm; 3 November 1967; dredge; FSBC

I 11090. — 1, 4.2 mm; 21 November 1967; trawl. — 6, 3.0-5.6 mm, 1 dead test, 5.2 mm; 21 November 1967; dredge. — HOURGLASS STATION E: 1, 6.5 mm; 7 June 1966; dredge. — 1 dead test, 3.8 mm; 3 July 1966; trawl. — 4, 2.9-8.4 mm; 2 August 1966; trawl; FSBC I 4469. — 16, 2.0-4.9 mm, 11 dead tests, 2.4-3.7 mm; 2 August 1966; dredge. — 19, 1.6-4.3 mm, 23 dead tests, 1.8-5.4 mm; 9 October 1966; dredge. — 3, 1.9-5.8 mm, 2 dead tests, 2.5, 3.8 mm; 9 November 1966; dredge. — 9, 1.8-4.3 mm; 9 November 1966; trawl. — 7, 2.3-6.8 mm; 2 December 1966; trawl; FSBC I 11080. — 28, 1.2-7.5 mm, 29 dead tests, 1.9-5.7 mm; 2 December 1966; dredge; FSBC I 6793. — 2, 4.0, 4.7 mm, 2 dead tests, 2.9, 4.9 mm; 6 February 1967; dredge. — 1 dead test, 1.8 mm; 3 March 1967; trawl. — 6, 2.4-5.4 mm, 3 dead tests, 2.3-7.4 mm; 3 March 1967; dredge; FSBC I 11081. — 3, 1.4-1.8 mm, 14 dead tests, 1.6-4.8 mm; 12 May 1967; dredge. — 1 dead test, 4.1 mm; 12 May 1967; trawl. — 13, 1.6-4.5 mm, 22 dead tests, 2.0-5.7 mm; 2 August 1967; dredge. — 2, 6.1, 9.4 mm; 6 October 1967; trawl. — 7, 1.1-5.0 mm, 3 dead tests, 2.2-3.2 mm; 6 October 1967; dredge. — 1, 6.5 mm; 3 November 1967; trawl. — HOURGLASS STATION K: 2 dead tests, 3.4, 5.7 mm; 6 December 1966; dredge. — 2, 4.1, 5.0 mm, 1 dead test, 8.3 mm; 5 July 1967; dredge; FSBC I 11084. — 1, 4.2 mm; 4 September 1967; dredge; FSBC I 11087. — 6 dead tests, 1.1-1.6 mm; 14 November 1967; dredge. — HOURGLASS STATION L: 1 dead test, 4.4 mm; 6 August 1966; trawl. — 8, 1.8-2.8 mm, 15 dead tests, 1.6-4.7 mm; 6 August 1966; dredge; FSBC I 4471. — 73, 1.4-6.8 mm, 143 dead tests, 1.6-6.4 mm; 5 September 1966; dredge; FSBC I 4104. — 8, 1.9-3.2 mm, 22 dead tests, 1.7-7.5 mm; 13 October 1966; dredge. — 3, 2.9-4.4 mm, 6 dead tests, 1.9-5.0 mm; 13 November 1967; dredge; FSBC I 11078. — 6, 1.9-4.0 mm, 5 dead tests, 3.5-5.9 mm; 7 December 1966; dredge. — 7, 2.6-5.8 mm, 1 dead test, 3.2 mm; 13 January 1967; trawl. — 1, 5.2 mm, 1 dead test, 3.6 mm; 13 January 1967; dredge. — 18, 2.9-5.1 mm, 23 dead tests, 2.3-6.0 mm; 16 February 1967; dredge. — 1, 3.6 mm, 6 dead tests, 2.5-5.0 mm; 9 March 1967; trawl. — 2, 3.6, 5.3 mm, 11 dead tests, 1.9-3.6 mm; 8 April 1967; dredge. — 4, 2.5-4.9 mm, 9 dead tests, 1.9-4.8 mm; 16 May 1967; dredge. — 9, 2.1-6.1 mm, 20 dead tests, 1.4-5.0 mm; 7 June 1967; dredge. — 4, 4.0-4.7 mm, 5 dead tests, 2.3-4.2 mm; 6 July 1967; trawl; FSBC I 11085. — 4, 2.5-7.5 mm, 7 dead tests, 2.4-5.9 mm; 6 July 1967; dredge. — 7, 2.1-5.2 mm, 9 dead tests, 2.0-5.2 mm; 8 August 1967; trawl. — 18, 1.6-7.2 mm, 33 dead tests, 2.0-7.3 mm; 8 August 1967; dredge. — 3, 4.2-8.1 mm, 4 dead tests, 2.2-4.0 mm; 5 September 1967; trawl; FSBC I 11088. — 5, 2.1-5.9 mm, 11 dead tests, 1.8-5.1 mm; 5 September 1967; dredge. — 7, 2.6-9.4 mm, 10 dead tests, 2.8-6.2 mm; 12 October 1967; dredge. — 7, 3.7-7.3 mm, 21 dead tests, 1.7-6.3 mm; 15 November 1967; trawl. — 12, 2.9-6.0 mm, 8 dead tests, 1.7-3.7 mm; 15 November 1967; dredge. — HOURGLASS STATION M: 3, 3.1-4.3 mm, 2 dead tests, 3.2, 3.5 mm; 14 January 1966; dredge. — 1, 4.7 mm; 15 February 1966; dredge; FSBC I 4467. — 1, 6.2 mm, 4 dead tests, 1.5-4.6 mm; 12 May 1966; dredge. — 1, 4.3 mm; 13 June 1966; dredge; FSBC I 11073. — 3, 2.5-3.2 mm; 6 July 1966; dredge. — 4, 2.5-5.0 mm; 6 August 1966; trawl; FSBC I 4472. — 3, 1.8-3.5 mm, 14 dead tests, 2.5-4.9 mm; 6 August 1966; dredge. — 4, 3.2-5.3 mm, 3 dead tests, 2.0-4.7 mm; 5 September 1966; trawl. — 295, 1.4-6.0 mm, 861 dead tests, 1.5-5.5 mm; 5 September 1966; dredge; FSBC I 4542. — 3, 2.4-5.6 mm, 11 dead tests, 2.1-4.3 mm; 13 October 1966; dredge; FSBC I 11075. — 11, 2.3-4.9 mm, 13 dead tests, 2.1-4.4 mm; 13 November 1966; dredge. — 1 dead test, 6.2 mm; 7 December 1966; trawl. — 1, 5.9 mm; 7 December 1966; dredge. — 2, 2.9, 3.0 mm, 2 dead tests, both 3.1 mm; 13 January 1967; dredge. — 7, 2.3-8.3 mm, 7 dead tests, 2.6-5.0 mm; 31 January 1967; trawl; FSBC I 4805. — 1 dead test, 2.2 mm; 16 February 1967; trawl. — 2 dead tests, 3.0, 3.5 mm; 8 April 1967; dredge. — 1 dead test, 2.1 mm; 16 May 1967; trawl. — 1, 6.0 mm, 1 dead test, 2.4 mm; 7 June 1967; dredge. — 6 dead tests, 2.4-4.7 mm; 6 July 1967; trawl. — 2, 2.2, 3.3 mm, 17 dead tests, 2.0-5.5 mm; 6 July 1967; dredge. — 4 dead tests, 2.4-3.7 mm; 8 August 1967; trawl. — 5 dead tests, 1.9-4.4 mm; 8 August 1967; dredge. — 3 dead tests, 3.2-4.6 mm; 5 September 1967; trawl. — 3, 1.8-3.1 mm, 36 dead tests, 2.0-6.6 mm; 5 September 1967; dredge. — 4 dead tests, 1.9-4.0 mm; 12 October 1967; dredge. — 4, 2.4-4.5 mm, 10 dead tests, 1.6-6.2 mm; 15 November 1967; dredge.

Diagnosis: Test small, regularly hemispherical, rarely exceeding 13 mm HD; tubercles non-crenulate; test sculpture of small, scattered depressions; oculars widely exsert; periproct with single, large, round, shiny,

suranal plate (exceptionally large specimens greater than 10 mm HD occasionally with few small accessory plates).

Distribution: *Genocidaris maculata* occurs in the western Atlantic from Cape Cod, Massachusetts to Florida and throughout the Gulf of Mexico. It occurs in the Lesser Antilles south of Antigua and along the South American coast from Colombia to Surinam. In the eastern Atlantic it occurs throughout the Mediterranean Sea and southward along the coast of Africa to the mouth of the Congo River. It is also known from the Azores and Canary Islands. It occurs in depths from 12 to 420 m, but is most common from 50 to 200 m.

Bottom type: In this study, *G. maculata* most frequently occurred on bottoms composed primarily of algal sand (*Lithothamnion* spp.) at offshore Stations C, D, E, K, L and M (Table 9).

TABLE 9. NUMBERS OF *GENOCIDARIS MACULATA* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Genocidaris maculata																																	
Sta	1965					1966													1967													Tot	
	A	S	O	N	D	J	F	M	A	M	J	J	J	sp	A	S	O	N	D	J	J	sp	F	M	A	M	J	J	A	S	O		N
A																																	
B ₁																																	
B ₂																																	
C ₁																		1		3			1	1	1		2	2		3	1	1	16
C ₂																			1	1									1	3		1	7
D ₁							1								16		44	11					1	3	5	3		5		22	8	3	122
D ₂												7			3	10	4	5	1				2			12		2	1	3	1	7	58
E											1				20		19	12	35				2	6		3			13		9	1	121
I																																	
J																																	
K																												2		1			3
L															8	73	8	3	6	8			18	1	2	4	9	8	25	8	7	19	207
M						3	1			1	1	3			7	299	3	11	1	2	7						1	2		3		4	349
TOT						3	2			1	2	10			54	382	78	43	44	14	7		24	11	8	22	12	21	40	43	26	36	883

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Diet: Lewis (1963) reported gut contents contained sand grains, foraminiferans, small gastropods and bryozoans.

Growth and reproduction: Size classes were not distinct in *G. maculata*, and growth data could not be obtained. A size frequency plot for specimens at Station M in September 1966 was the only sample large enough to suggest size classes for *G. maculata* (Figure 17). The plot seems to be a bimodal curve with modes at 2.2 and 4.3 mm HD. The first mode could represent individuals spawned the previous spring, and the second mode could represent individuals spawned the year before, but the data are too few to interpret with any certainty.

The only data available on spawning is from Mortensen (1943), who found *G. maculata* gonads ripe in March at the Canary Islands. Genital pores of Hourglass specimens developed at sizes from 2.5 to 4.9 mm HD.

Population dynamics: Size frequency plots for *G. maculata* at Stations C, D, E, K, L and M for all months suggest that shoreward stations (C and K) have relatively small populations (Figure 18). The largest population was found at Station M.

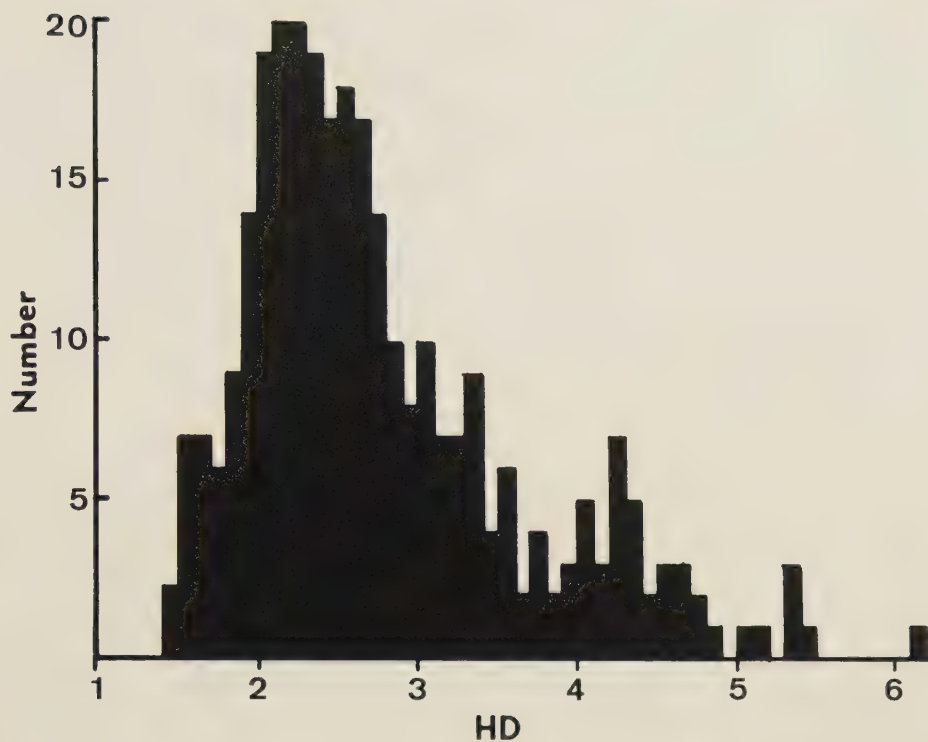


Figure 17. Size frequency plot for *G. maculata*, Station M, September 1966. HD in mm. N = 299.

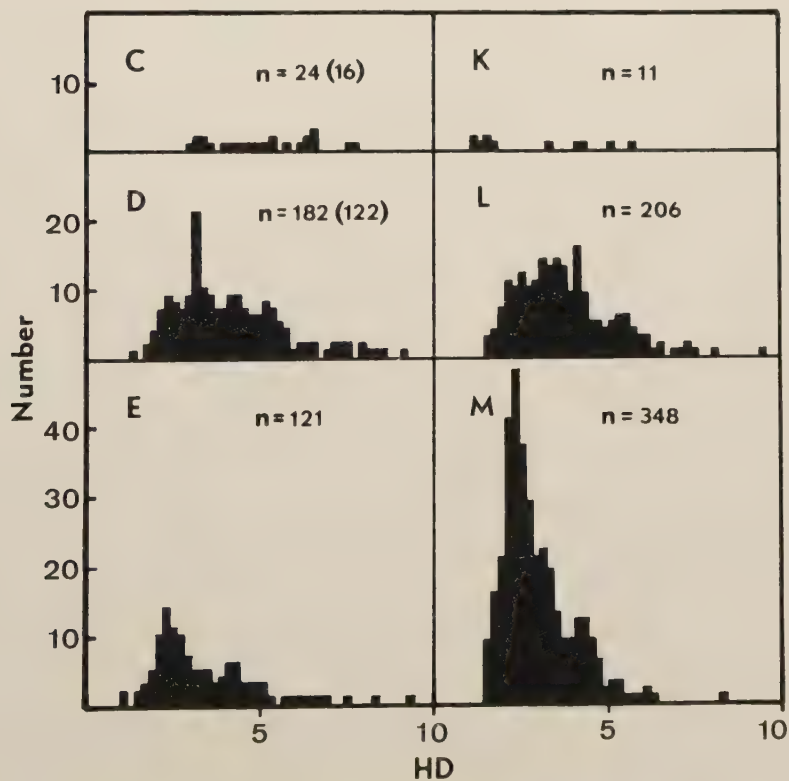


Figure 18. Size frequency plots for *G. maculata*, Stations C, D, E, K, L and M, duration of study. N = numbers of specimens; numbers in parentheses represent specimens collected in regular cruises only.

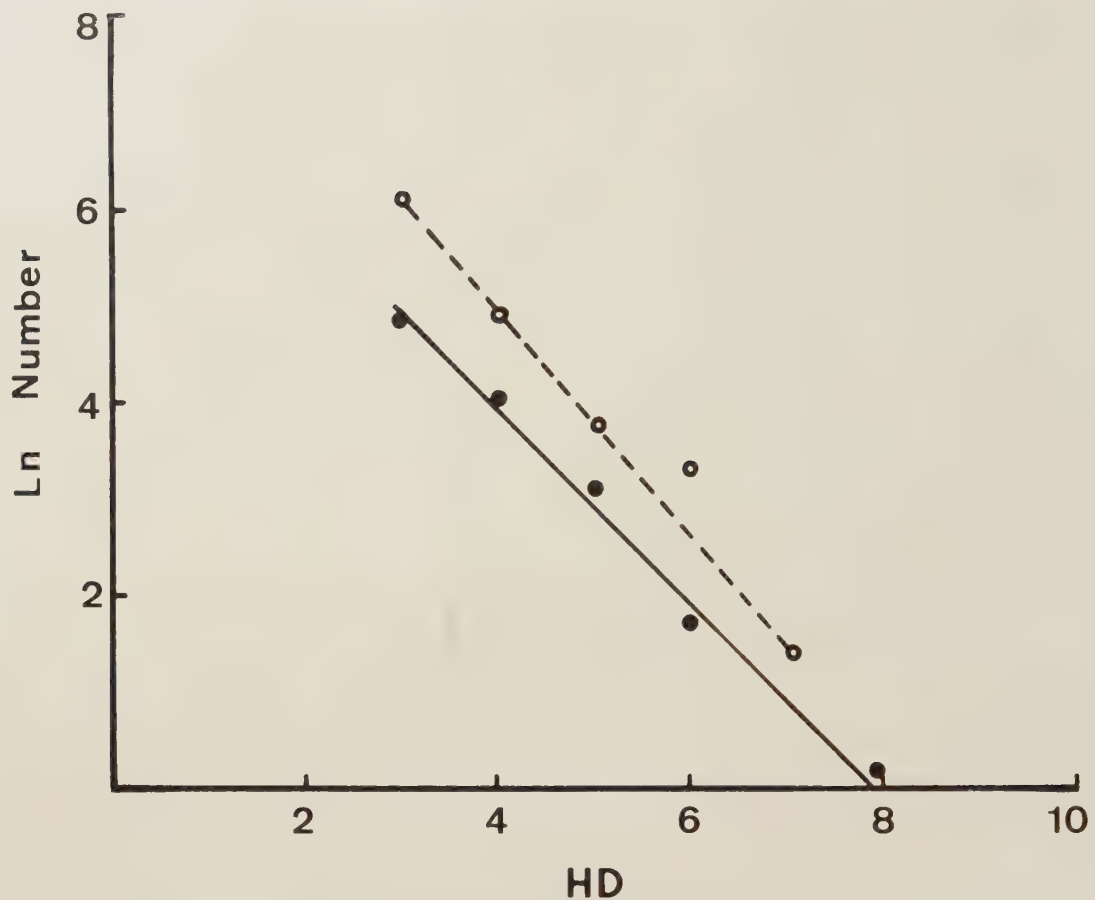


Figure 19. Natural logarithm of number of *G. maculata* collected at Station M as function of size. Closed circles = living specimens; open circles = dead tests. Slope of line for living specimens = -0.99 ($a_{mm} = 63$ percent); slope of line for dead tests = -1.14 ($a_{mm} = 68$ percent).

Figure 19 shows the natural log of the number of *G. maculata* collected at Station M as a function of size. Only specimens greater than 2.5 mm HD were considered, since net selection occurred in smaller specimens. Closed circles represent specimens living when collected, and open circles represent dead tests. Mortality per 1 mm increase in HD (a_{mm}) is 63 percent for living specimens ($N = 213$) and 68 percent for the dead tests ($N = 631$). These mortalities should be equal theoretically and are close enough for the purpose of this study. They cannot be compared to the values obtained for *A. punctulata* (Figure 14), since *G. maculata* is a much smaller species. These mortalities can only be used for intraspecific comparisons. Theoretical maximum size, obtained by extending the line to the x-axis, is approximately 8 mm HD in both cases. The largest specimen collected in this study was 9.5 mm HD. Mortensen (1943) states the largest specimen known is 12.7 mm HD, but Lewis (1963) records two larger specimens, 18 and 20 mm HD. Since larger specimens have been recorded elsewhere, it is possible that the population in the Gulf of Mexico is stunted. Unlike *Arbacia punctulata*, *Genocidaris maculata* showed no decrease in mortality at sexual maturity.

Gear selectivity: The dredge was far better for collecting *G. maculata*; 2298 specimens were collected by dredge and 262 by trynet.

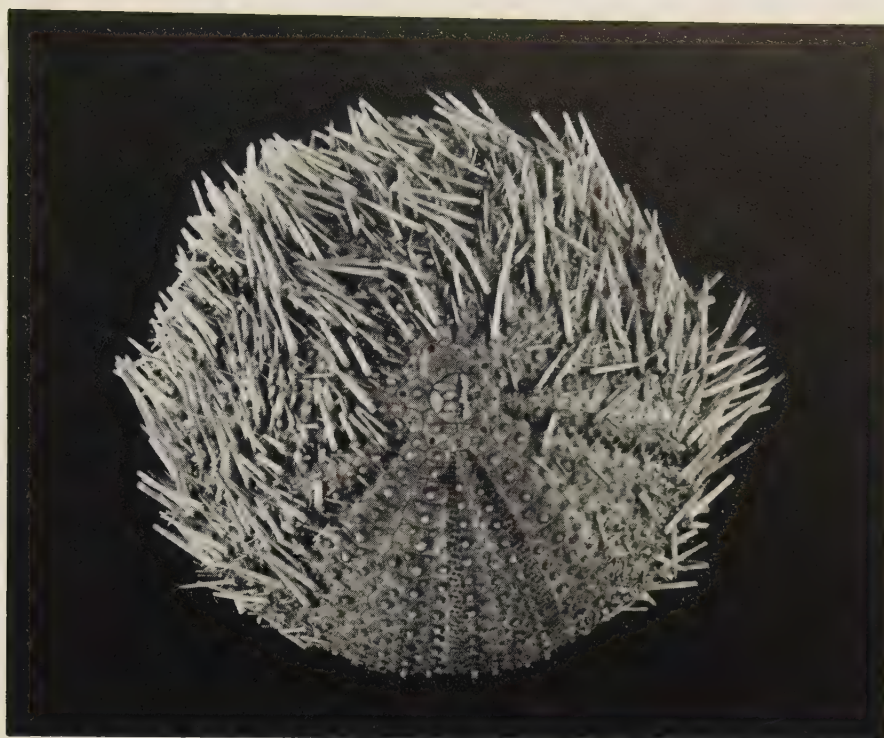


Figure 20. *Lytechinus euerces*, aboral aspect, 42 mm HD; Station L, December 1965; FSBC I 11012.

Family Toxopneustidae Troschel, 1872

Lytechinus euerces H. L. Clark, 1912

Figure 20

Lytechinus euerces H. L. Clark, 1912, p. 247, pl. 93, figs. 4, 5, pl. 98, figs. 3, 4, pl. 107, figs. 4-6; 1918, p. 29; 1921, p. 112; Mortensen, 1943, p. 460, pl. 52, figs. 6-9, 15, pl. 53, fig. 23; Mayr, 1954, p. 7, fig. 5; Lewis, 1961, p. 52; 1963, p. 361; Chesher, 1968b, p. 6; Serafy, 1973, p. 525.

Material examined: HOURGLASS STATION D: 1, 43.8 mm; 7 April 1966; trawl; FSBC I 2753. — 1, 26.5 mm; 3 May 1966; dredge; FSBC I 2787. — HOURGLASS STATION E: 1, 28.0 mm; 9 October 1966; dredge; FSBC I 3951. — HOURGLASS STATION L: 1, 42.3 mm; 13-14 December 1965; trawl; FSBC I 11012. — HOURGLASS STATION M: 1, 16.5 mm; 5 September 1966; trawl; FSBC I 4019. — 1, 19.9 mm; 31 January 1967; trawl; FSBC I 4803.

Diagnosis: Test low, hemispherical; ambulacral plates trigeminate, each with primary tubercle; secondary ambulacral tubercles not in regular series; peristomal membrane heavily plated; secondary tuberculation scattered irregularly over test, leaving no naked areas in aboral portions of ambulacra and interambulacra; spicules of globiferous pedicellariae C-shaped; test and spines whitish, with some light green adapically; 13 or 14 wedges in cross-sections of primary spines.

Distribution: *Lytechinus euerces* occurs offshore from Charleston, South Carolina, southward through the Greater and Lesser Antilles to Trinidad Island. In the eastern Gulf it occurs as far north as off St. Petersburg, Florida and south along the Yucatan Peninsula to Belize, British Honduras. It is not known from the Central and South American coasts between Belize and Trinidad. It occurs in depths from 55 to 777 m. Hourglass specimens represent a northern range extension in the Gulf and a new shallow record for the species.

Bottom type: Hourglass specimens of *L. euerces* occurred on bottoms composed primarily of algal sand (*Lithothamnion* spp.) at offshore Stations D, E, L and M.

Diet: Lewis (1963) reported that gut contents of one specimen consisted of rounded fecal pellets containing coral or calcareous shell surrounded by flocculent white material. Fragments of bryozoans, worm tubes and sponge were also present.

Morphometric and meristic relationships: Six measurements and three counts were taken on five specimens of *L. euerces* from 16 to 44 mm HD. Linear regression data for various characters as a function of HD are presented (Table 10) for comparison with the congener *L. variegatus carolinus*.

TABLE 10. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS AS A FUNCTION OF HD IN *L. EUERCES* AND *L. VARIEGATUS CAROLINUS**.

Character	Species	Regression Equation	$s_{y,x}$	r
TH	<i>L. euerces</i>	$y = 0.57x + 0.30$	0.39	1.00
	<i>L. v. carolinus</i>	$y = 0.60x - 1.91$	1.96	0.98
AS	<i>L. euerces</i>	$y = 0.16x + 1.59$	0.64	0.96
	<i>L. v. carolinus</i>	$y = 0.15x + 1.10$	0.51	0.98
PP	<i>L. euerces</i>	$y = 0.093x + 0.34$	0.37	0.96
	<i>L. v. carolinus</i>	$y = 0.091x + 0.21$	0.37	0.97
IA	<i>L. euerces</i>	$y = 0.35x + 8.90$	0.68	0.99
	<i>L. v. carolinus</i>	$y = 0.30x + 10.15$	1.30	0.96
TUB	<i>L. euerces</i>	$y = 1.65x - 0.30$	5.51	0.97
	<i>L. v. carolinus</i>	$y = 1.67x - 12.06$	8.33	0.95
AMB	<i>L. euerces</i>	$y = 0.58x + 7.74$	1.04	0.99
	<i>L. v. carolinus</i>	$y = 0.48x + 11.21$	1.85	0.97
PS	<i>L. euerces</i>	$y = 0.32x + 1.98$	0.40	1.00
	<i>L. v. carolinus</i>	$y = 0.26x + 3.79$	0.71	0.98
SL	<i>L. euerces</i>	$y = 0.11x + 6.00$	0.64	0.90
	<i>L. v. carolinus</i>	$y = 0.16x + 6.54$	1.90	0.79
SD	<i>L. euerces</i>	$y = 0.010x + 0.27$	0.032	0.97
	<i>L. v. carolinus</i>	$y = 0.011x + 0.50$	0.089	0.88

*All characters (ordinates) plotted as function of HD (abscissa). All measurements in mm; $s_{y,x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 5 for *L. euerces*, and 132 for *L. v. carolinus*.

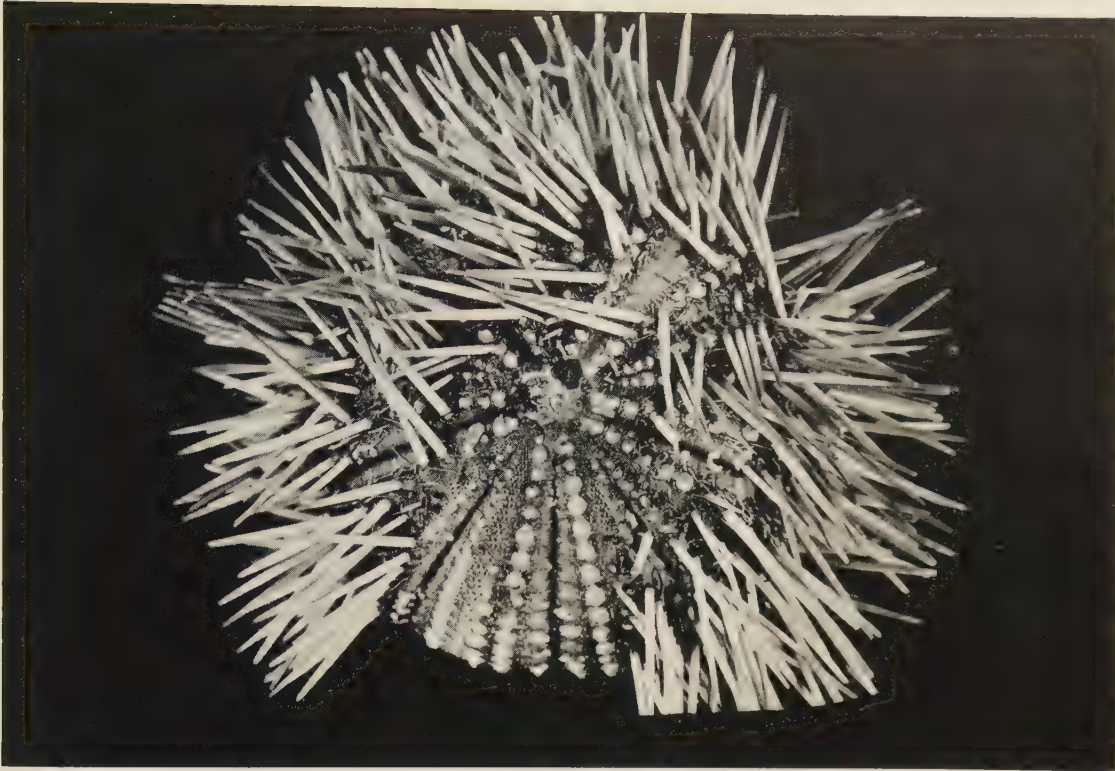


Figure 21. *Lytechinus variegatus carolinus*, aboral aspect, 45 mm HD; Station B, August 1967; FSBC I 11029.

Lytechinus variegatus carolinus A. Agassiz, 1863

Figure 21

Echinus variegatus Lamarck, 1816, p. 48; Blainville, 1825, p. 83; Say, 1827, p. 226.

Echinus excavatus Blainville, 1825, p. 83.

Echinus blainvilli Desmoulins, 1837, p. 122.

Psammechinus variegatus: L. Agassiz and Desor, 1846, p. 368.

Psammechinus excavatus: L. Agassiz and Desor, 1846, p. 369.

Lytechinus carolinus A. Agassiz, 1863, p. 24.

Psilechinus variegatus: Lütken, 1864, p. 93.

Lytechinus variegatus: A. Agassiz, 1869, p. 264; Mortensen, 1921, p. 35, pl. 3, figs. 1, 2, pl. 8, fig. 1; Whitten et al., 1950, p. 85; Mayr, 1954, p. 7, fig. 5; Hildebrand, 1955, p. 196; Sharp and Gray, 1962, p. 309; Moore et al., 1963, pp. 23-53, figs. 1-22; Dragovich and Kelly, 1964, p. 93; Moore and McPherson, 1965, p. 856, figs. 1, 3, 5, 7; Thomas and Thomas, 1965, p. 196; Tommasi, 1966b, p. 14, text-figs. 16-21, pl. 4a; Randall, 1967, pp. 723, 732, 766, 769, 771, 815; Roa, 1967, p. 301; Godcharles, 1971, p. 27; Lyons et al., 1971, p. 38; Menzel, 1971, p. 86; Jolley, 1972, p. 37; Moore and Lopez, 1972, pp. 275-280, figs. 1-9; Camp et al., 1973, pp. 37, 38, figs. 1, 2; Godcharles and Jaap, 1973, p. 51; Hopkins et al., 1977, p. 35.

Schizechinus variegatus: Pomel, 1869, p. 42.

Schizechinus excavatus: Pomel, 1869, p. 42.

Toxopneustes variegatus: A. Agassiz, 1872, pp. 168, 298, pl. 2, figs. 5, 6, pl. 4a, figs. 4, 5, pl. 7, figs. 7-20; 1878, p. 189; 1880, p. 78; Rathbun, 1885, p. 613; 1886, p. 279.

Lytechinus variegatus carolinus: H. L. Clark, 1912, p. 247; 1918, p. 30; Tortonese, 1933, p. 123; Mortensen, 1943, p. 437, pl. 24, figs. 1-9, pl. 25, figs. 1-12, pl. 53, figs. 1, 6, 7, 11-13; A. H. Clark, 1954, p. 374; Cheshier, 1968b, p. 6; Eastwood, 1972, pp. 1-171; Serafy, 1973, p. 525.

Material examined: HOURGLASS STATION A: 38, 15.0-73.0 mm; 3 August 1965; trawl. — 2 juveniles; 3 August 1965; dredge. — 11, 28.0-75.0 mm; 30 August 1965; trawl. — 8 adults; 30 August 1965; dredge. — 1 adult; 4 October 1965; trawl. — 20 adults; 4 October 1965; dredge. — 14, 42.0-68.0 mm; 8 November 1965; dredge. — 11, 37.3-61.0 mm; 3 December 1965; trawl; FSBC I 1322. — 23, 48.0-70.0 mm; 3 December 1965; dredge. — 3, 50.0-52.0 mm; 3 January 1966; trawl. — 16, 42.0-63.0 mm; 3 January 1966; dredge. — 15, 45.0-66.0 mm; 3 March 1966; trawl. — 21, 45.0-60.0 mm; 3 March 1966; dredge. — 21, 54.0-73.0 mm; 6 April 1966; trawl. — 21, 42.0-68.0 mm; 6 April 1966; dredge. — 5, 57.0-68.0 mm; 2 May 1966; trawl. — 18 adults; 2 May 1966; dredge. — 4, 58.0-64.0 mm; 6 June 1966; trawl. — 45, 22.0-74.0 mm; 6 June 1966; dredge. — 1, 19.0 mm; 2 July 1966; trawl. — 3, 6.0-8.0 mm; 2 July 1966; dredge. — 26, 35.0-68.0 mm; 1 August 1966; dredge. — 30, 3.2-70.0 mm; 31 August 1966; dredge; FSBC I 4462. — 3, 35.0-68.0 mm; 8 October 1966; trawl. — 8, 11.0-61.0 mm; 8 October 1966; dredge. — 2, 49.0, 56.1 mm; 6 November 1966; dredge. — 1, 56.0 mm; 6 January 1967; dredge. — 3, 49.2-58.6 mm; 5 February 1967; dredge. — 1, 60.4 mm; 2 March 1967; dredge; FSBC I 11018. — 4, 47.7-60.4 mm; 3 April 1967; dredge. — 8, 2.0-66.0 mm; 11 May 1967; dredge. — 16, 3.0-63.9 mm; 2 June 1967; dredge. — 11, 12.2-63.8 mm; 1 July 1967; dredge. — 63, 13.6-65.3 mm; 1 August 1967; dredge. — 6, 22.7-66.7 mm; 31 August 1967; trawl. — 54, 13.7-75.0 mm; 31 August 1967; dredge; FSBC I 11031. — 156, 11.6-63.4 mm; 5 October 1967; dredge. — 3, 13.0-54.7 mm; 2 November 1967; trawl. — HOURGLASS STATION B: 4 adults; 3 August 1965; trawl. — 3 adults; 3 August 1965; dredge. — 5 adults; 26 August 1965; dredge. — 2 adults; 30 August 1965; trawl. — 1 adult; 4 October 1965; dredge. — 26 adults; 20 October 1965; trawl. — 28 adults; 20 October 1965; dredge. — 10, 50.0-60.0 mm; 8 November 1965; trawl. — 10, 50.0-60.0 mm; 8 November 1965; dredge. — 1, 60.0 mm; 19 November 1965; dredge. — 10, 53.0-65.0 mm; 3 December 1965; dredge. — 1, 10.4 mm; 3 January 1966; trawl; FSBC I 1535. — 3, 49.0-60.0 mm; 19 January 1966; trawl. — 1, 60.0 mm; 19 January 1966; dredge. — 7, 4.0-19.9 mm; 7 February 1966; trawl; FSBC I 1889. — 5, 8.0-65.0 mm; 7 February 1966; dredge. — 1, 11.0 mm; 3 March 1966; trawl. — 1, 19.0 mm; 3 March 1966; dredge. — 1, 10.0 mm; 26 March 1966; trawl. — 1, 16.0 mm; 26 March 1966; dredge. — 3, 63.0-70.0 mm; 15 April 1966; trawl. — 3, 63.0-65.0 mm; 15 April 1966; dredge. — 1 adult, 2 juveniles; 2 May 1966; trawl. — 5, 20.0-80.0 mm; 18 May 1966; trawl. — 6, 11.0-72.0 mm; 18 May 1966; dredge. — 1, 14.0 mm; 6 June 1966; dredge. — 1, 12.0 mm; 17 June 1966; trawl. — 1, 8.0 mm; 17 June 1966; dredge. — 2, 9.0, 69.0 mm; 2 July 1966; trawl. — 2, 70.0, 74.0 mm; 2 July 1966; dredge. — 1, 75.0 mm; 10 July 1966; trawl. — 2, 22.0, 66.0 mm; 18 July 1966; trawl. — 4, 10.0-70.0 mm; 1 August 1966; dredge. — 3, 3.0-10.3 mm; 18 October 1966; dredge; FSBC I 11014. — 1, 42.7 mm; 6 January 1967; dredge; FSBC I 11016. — 2, 8.4, 49.0 mm; 25 January 1967; trawl. — 1, 71.6 mm; 14 March 1967; trawl; FSBC I 11020. — 1, 73.4 mm; 3 April 1967; trawl. — 2, 2.5, 4.7 mm; 20 May 1967; dredge. — 1, 10.1 mm; 2 June 1967; trawl. — 6, 10.3-23.5 mm; 2 June 1967; dredge; FSBC I 11023. — 1, 14.4 mm; 20 June 1967; dredge. — 2, 13.4, 25.0 mm; 1 July 1967; trawl. — 12, 7.0-75.1 mm; 1 July 1967; dredge. — 1, 18.2 mm; 11 July 1967; trawl. — 1, 44.6 mm; 1 August 1967; trawl; FSBC I 11029. — 3, 14.0-40.3 mm; 1 August 1967; dredge; FSBC I 11030. — 2, 4.5, 40.9 mm; 11 August 1967; dredge. — 3, 10.5-19.3 mm; 31 August 1967; trawl. — 5, 2.8-53.1 mm; 31 August 1967; dredge. — 1, 79.4 mm; 11 September 1967; trawl. — 1, 33.7 mm; 11 September 1967; dredge. — 3, 12.8-50.0 mm; 5 October 1967; trawl. — 7, 3.4-21.7 mm; 5 October 1967; dredge. — 2, 45.7, 46.0 mm; 2 November 1967; trawl. — 29, 1.0-60.0 mm; 2 November 1967; dredge. — 6, 6.2-63.3 mm; 20 November 1967; dredge. — HOURGLASS STATION C: 1, 23.0 mm; 8 November 1965; trawl. — 1, 18.0 mm; 20 February 1966; dredge. — 1, 31.0 mm; 27 March 1966; dredge. — 1, 32.0

mm; 6 April 1966; trawl. — 1, 24.0 mm; 16 April 1966; trawl. — 5, 40.2-49.0 mm; 2 May 1966; trawl. — 1, 38.0 mm; 19 May 1966; trawl. — 1, 23.0 mm; 2 July 1966; dredge. — 1, 32.0 mm; 11 July 1966; trawl. — 1, 41.0 mm; 1 August 1966; dredge. — 3, 9.0-34.0 mm; 11 August 1966; trawl. — 1, 7.0 mm; 31 August 1966; trawl. — 1, 10.7 mm; 18 October 1966; dredge; FSBC I 4816. — 2, 4.7, 30.0 mm; 6 November 1966; trawl. — 2, 29.9, 32.5 mm; 1 December 1966; dredge. — 1, 59.0 mm; 6 January 1967; dredge. — 3, 2.0-47.0 mm; 2 March 1967; dredge. — 1, 14.7 mm; 11 May 1967; trawl; FSBC I 11021. — 3, 11.0-24.4 mm; 11 May 1967; dredge. — 1, 13.0 mm; 20 May 1967; trawl. — 2, 8.7, 15.0 mm; 2 June 1967; dredge; FSBC I 11024. — 3, 14.7-18.0 mm; 21 June 1967; trawl. — 1, 26.0 mm; 21 June 1967; dredge; FSBC I 11026. — 1, 17.4 mm; 1 July 1967; trawl. — 3, 19.7-50.2 mm; 1 July 1967; dredge. — 5, 9.6-28.2 mm; 11 July 1967; trawl. — 12, 22.2-64.0 mm; 1 August 1967; trawl. — 3, 25.6-34.2 mm; 11 August 1967; trawl. — 13, 20.5-41.3 mm; 11 August 1967; dredge. — 1, 27.3 mm; 31 August 1967; trawl. — 3, 35.7-41.9 mm; 11 September 1967; trawl. — 1, 30.0 mm; 11 September 1967; dredge; FSBC I 11033. — 4, 34.8-56.4 mm; 5 October 1967; trawl. — 4, 16.7-43.0 mm; 25 October 1967; trawl. — 53, 15.4-59.0 mm; 2 November 1967; trawl; FSBC I 11035. — 19, 3.8-63.6 mm; 2 November 1967; dredge. — 1, 65.7 mm; 21 November 1967; trawl. — 5, 12.2-52.0 mm; 21 November 1967; dredge. — HOURGLASS STATION D: 15, 34.0-65.0 mm; 3 May 1966; trawl. — 3, 23.0-52.0 mm; 3 May 1966; dredge. — 1, 73.2 mm; 11 July 1966; trawl; FSBC I 3363. — 1, 21.0 mm; 19 October 1966; trawl. — 1, 20.0 mm; 19 October 1966; dredge. — 1, 20.2 mm; 20 November 1966; trawl. — 1, 35.2 mm; 2 December 1966; trawl. — 1, 37.5 mm; 14 December 1966; trawl; FSBC I 11015. — 1, 1.8 mm; 28 February 1967; dredge; FSBC I 11017. — 1, 37.1 mm; 15 March 1967; trawl. — 1, 1.9 mm; 15 March 1967; dredge. — 4, 1.6-5.7 mm, 1 dead test, 2.9 mm; 21 May 1967; dredge. — 1, 7.6 mm; 12 July 1967; dredge. — 1, 11.2 mm; 12 September 1967; trawl. — 1, 14.0 mm; 12 September 1967; dredge. — 1, 41.6 mm; 6 October 1967; dredge. — 2, 25.2, 26.9 mm; 3 November 1967; trawl. — HOURGLASS STATION I: 12 adults; 6 August 1965; trawl. — 4 adults; 6 August 1965; dredge. — 15, 29.0-48.0 mm; 12 November 1965; trawl. — 37, 26.0-56.0 mm; 12 November 1965; dredge. — 27, 34.0-50.0 mm; 6 December 1965; trawl. — 63, 17.0-64.0 mm; 6 December 1965; dredge. — 16, 13.7-52.5 mm; 13 January 1966; dredge. — 9, 33.0-56.0 mm; 14 February 1966; dredge. — 29, 33.0-57.0 mm; 9 March 1966; trawl. — 11, 37.0-50.0 mm; 21 March 1966; trawl. — 29, 27.0-53.0 mm; 21 March 1966; dredge. — 25, 29.0-68.0 mm; 11 April 1966; trawl. — 110, 17.0-53.0 mm; 11 April 1966; dredge. — 77, 46.0-69.0 mm; 11 May 1966; trawl. — 39, 18.0-52.0 mm; 11 May 1966; dredge. — 2, 31.0, 37.0 mm; 12 June 1966; trawl. — 6, 13.0-49.0 mm; 12 June 1966; dredge. — 6, 30.0-56.0 mm; 5 July 1966; trawl. — 26, 16.0-50.0 mm; 5 July 1966; dredge. — 9, 14.0-47.0 mm; 5 August 1966; dredge. — 6, 2.0-3.6 mm; 15 May 1967; dredge; FSBC I 11022. — 29, 3.0-14.8 mm; 6 June 1967; dredge; FSBC I 11025. — 13, 6.3-20.8 mm; 5 July 1967; dredge; FSBC I 11027. — 91, 11.7-32.0 mm; 7 August 1967; dredge. — 6, 17.3-21.2 mm; 4 September 1967; trawl. — 186, 10.8-30.8 mm; 4 September 1967; dredge; FSBC I 11028. — 1, 18.0 mm; 11 October 1967; trawl. — 13, 8.9-35.8 mm; 11 October 1967; dredge. — 37, 19.2-43.9 mm; 14 November 1967; trawl. — 110, 6.3-52.9 mm; 14 November 1967; dredge. — HOURGLASS STATION J: 1 adult; 3 September 1965; dredge. — 1, 65.0 mm; 14 February 1966; trawl. — 1, 75.5 mm; 9 March 1966; trawl. — 1, 62.0 mm; 21 March 1966; trawl. — 1, 43.0 mm; 11 April 1966; trawl. — 2, 48.6, 55.7 mm; 8 March 1967; dredge; FSBC I 11019. — 2, 11.8, 21.0 mm; 5 July 1967; dredge. — 2, 30.7, 42.6 mm; 11 October 1967; trawl. — 4, 12.9-51.2 mm; 14 November 1967; trawl. — 32, 1.3-47.9 mm; 14 November 1967; dredge; FSBC I 11036. — HOURGLASS STATION K: 2 adults; 4 September 1965; trawl. — 1, 13.0 mm; 5 July 1966; trawl. — 1, 14.0 mm; 5 August 1966; dredge. — 2, 26.0, 34.0 mm; 4 September 1966; dredge. — 2, 6.3, 15.1 mm; 6 June 1967; trawl. — adult fragments; 5 July 1967; trawl. — 2, 18.3, 29.4 mm; 5 July 1967; dredge. — 1, 20.9 mm; 4 September 1967; trawl; FSBC I 11032. — 1, 10.8 mm; 11 October 1967; dredge. — HOURGLASS STATION L: 1, 45.0 mm; 14 January 1966; trawl. — 1, 41.0 mm; 22 March 1966; trawl. — 1, 58.0 mm; 12 April 1966; dredge. — 1, 17.8 mm; 6 July 1966; trawl. — 1, 21.0 mm; 6 August 1966; trawl. — 1, 5.0 mm; 5 September 1966; dredge; FSBC I 4103. — 1, 34.4 mm; 7 December 1966; trawl. — 1, 4.7 mm; 16 May 1967; dredge. — 1, 4.6 mm; 7 June 1967; trawl. — 1, 5.4 mm; 7 June 1967; dredge. — 1, 11.7 mm; 6 July 1967; dredge. — 5, 14.0-17.5 mm; 8 August 1967; trawl. — 1, 14.2 mm; 8 August 1967; dredge. — 2, 25.0, 30.0 mm; 5 September 1967; trawl. — 3,

urchins averaged 40 mm HD and were estimated to be approximately one year old. Large areas of grass beds were completely denuded, and no one knows what caused these urchin population "explosions."

Growth and reproduction: Early growth of *L. v. carolinus* at Stations A and I from April through November 1967 is illustrated in Figure 22. By extrapolation, it can be estimated that these specimens metamorphosed in early April 1967. They reached a size of about 26 mm HD seven months after metamorphosis. Moore et al. (1963) show growth curves for *L. variegatus* from 15 to 55 mm HD collected near Miami, Florida. Growth rates from their data are similar to those seen in Figure 22. According to data of Moore et al. (1963), growth slows considerably at about 45 mm HD and about eight months after metamorphosis. The test only increases about 10 mm HD in the next six months. They attribute this decrease in growth rate of the test to gamete production.

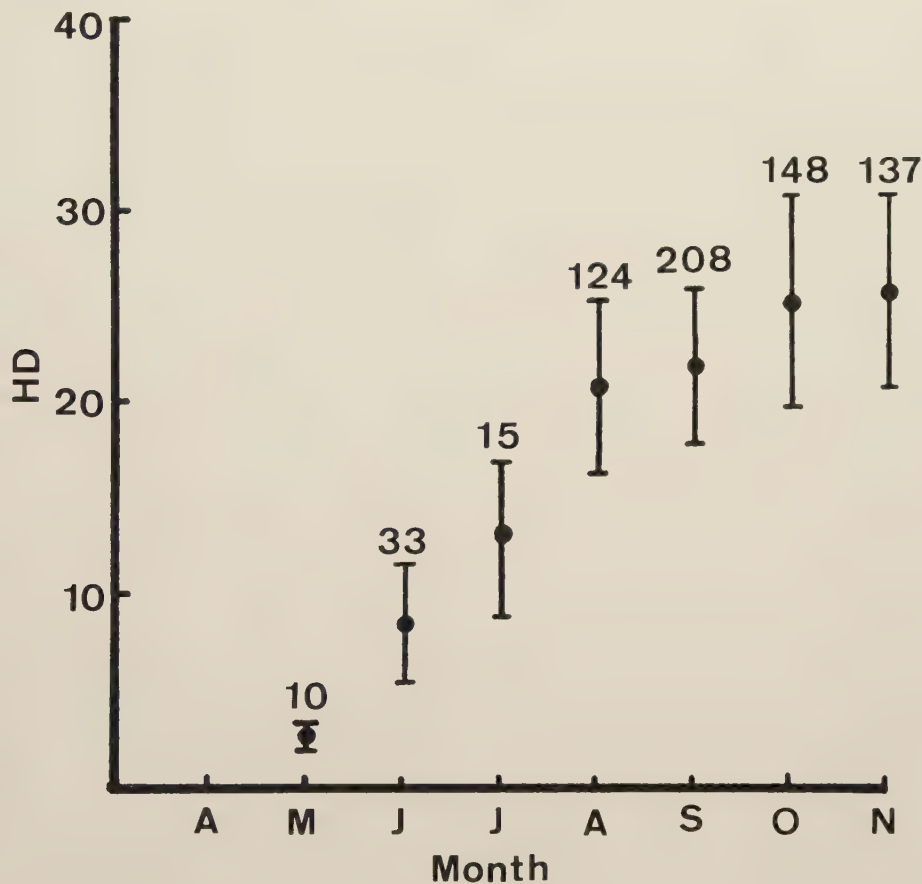


Figure 22. Early growth (mm) of *L. variegatus carolinus*, Stations A and I, April-November 1967. Brackets indicate one standard deviation of mean; figures above brackets indicate numbers of specimens.

Moore et al. (1963) found an inverse relationship between the rate of test growth and increasing water temperature. Moore and McPherson (1965) believed that diurnal and tidal temperature fluctuations might depress the feeding rate significantly in summer, but not winter, while having little effect on respiration. Such differential depression of feeding response at higher temperatures, together with higher respiratory rates in summer, might be sufficient to account for the observed relation of growth to temperature.

Genital pores developed in Hourglass specimens from 8.8 to 18.1 mm HD. However, Moore et al. (1963) reported that gonads do not develop until 35 to 40 mm HD, and spawning can occur as early as the end

of the first year's growth. Specimens attain sizes of about 60 mm HD at the end of the second year, which Moore et al. (1963) considered to be the normal life span. The few specimens 70 to 80 mm HD are believed to be three and four years old.

According to Eastwood (1972), the larval life of *L. v. carolinus* at 22 to 26°C is 41 to 58 days, and juveniles are 0.4 mm HD at metamorphosis. If this six to eight-week span is correct, then specimens shown in Figure 23 would have been spawned around February 1967. Moore et al. (1963) stated that *L. v. atlanticus* spawns in Bermuda from middle April to early June. In Miami, they found spawning occurred from February to September, although some individuals were ripe throughout the year. Moore and Lopez (1972) found that spawning time and gonad size are related to rainfall and temperature, at least in inshore populations of *L. variegatus*.

Small juveniles were present in the populations at Stations A, B, I and J in the fall of 1965 and throughout 1966.

Population dynamics: Size frequency plots for *L. v. carolinus* at Stations A and I and Stations B and J from April through November, 1967 are shown in Figure 23. Recruitment occurred at the two inshore and the two offshore populations in April, but occurred only in the offshore populations (B and J) in the early fall (September and October).

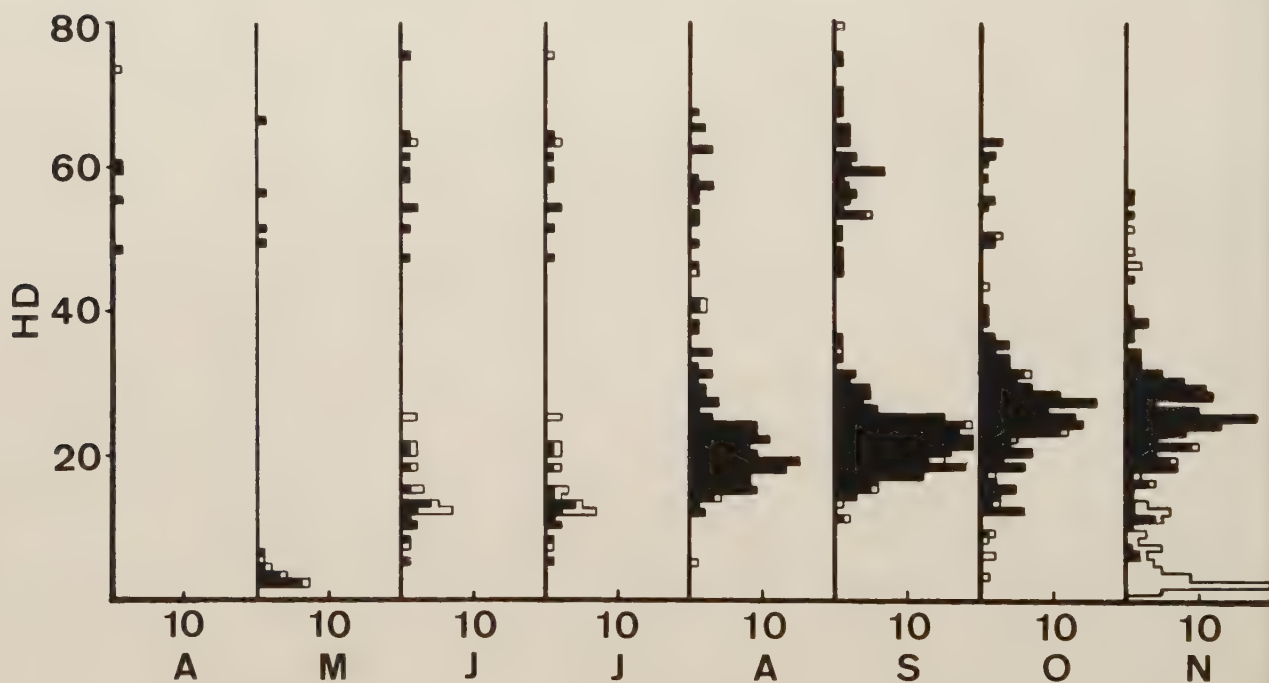


Figure 23. Size frequency plots for *L. variegatus carolinus*, Stations A and I (closed blocks) and Stations B and J (open blocks), April-November 1967. HD in mm.

From August 1965 to October 1966, many specimens were measured and discarded. Unfortunately, the mean and range of HD were usually all that was recorded, so size frequency plots prior to October 1966 are impossible to construct. Seasonal abundance data (Figure 24) can be used to interpret events during the early part of the study. The last part of Figure 24 can be interpreted with the aid of Figure 23 for the same time

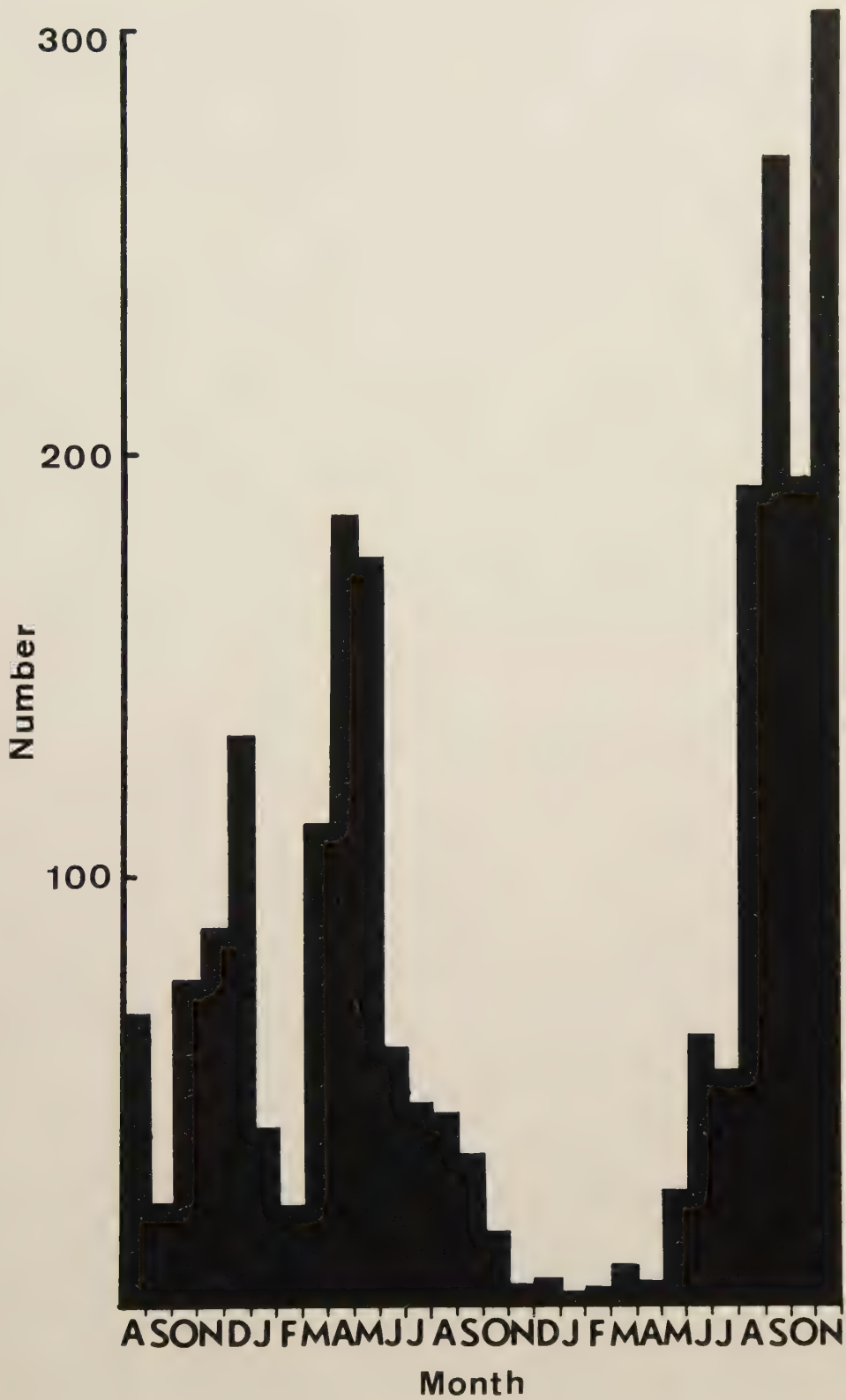


Figure 24. Seasonal abundance of *L. variegatus carolinus*, all stations combined, August 1965-November 1967.

period. The April 1967 recruitment calculated from Figure 23 does not appear in the catch until about one month later when the specimens are large enough to be collected. The continual increase in number (Figure 24) from May to September does not reflect continual recruitment. Instead, as specimens recruited in April grew larger, they became more vulnerable to the gear. No significant recruitment occurred during summer (Figure 23). The October 1967 recruitment calculated from Figure 23 again appears one month later as an increase in November. Considering this one-month lag, the first part of Figure 24 can be interpreted. A fall settlement probably occurred in September 1965 followed by a spring recruitment in February 1966. No fall recruitment is apparent for 1966, and the population dropped to a very low level. According to Williams and Ingle (1972), a red-tide bloom of *Gonyaulax monilata* Howell occurred along southwest Florida in August and September, 1966. Notes in the log of the R/V *Hernan Cortez* state there was a very unpleasant odor present in samples taken at Station I on September 4, 1966. Plankton tows taken at this time showed a *G. monilata* concentration of 210,000/liter. This red-tide bloom is believed to have caused the decrease in the population of *L. v. carolinus* (Figure 24) during the fall of 1966. Several species of mollusks are also believed to have been adversely affected by the red tide (W. G. Lyons, personal communication).

Gear selectivity: The dredge collected 1496 adults and 157 juveniles, while the trynet collected 607 adults and 26 juveniles.

Morphometric and meristic relationships: Six measurements and three counts were taken on 132 *L. v. carolinus* from 12.4 to 78.4 mm HD. Linear regression data for various characters as a function of HD are presented in Table 10. Serafy (1973) discussed morphometric differences among subspecies of *L. variegatus*.

Predators: According to Moore et al. (1963) and Thomas and Thomas (1965), herring gulls (*Larus argentatus* Pontoppidan) prey upon *L. variegatus* when they are exposed, or nearly so, dropping tests on the beach to break them. Gulls did not take urchins which were submerged by more than a few centimeters. Randall (1967) recorded *L. variegatus* from stomachs of the following species of West Indian fishes: *Haemulon album* Cuvier, *Calamus bajonado*, *Halichoeres bivittatus*, *H. poeyi*, *H. radiatus* and *Lactophrys trigonus* (Linne).

Remarks: Small juvenile *L. variegatus* (less than 5 mm HD) are often confused with *Genocidaris maculata*. Small *L. variegatus* have one large suranal plate with two or more supplementary periproctal plates, but *G. maculata* have no supplementary periproctal plates at that size. Genital pores develop in *G. maculata* from 2.5 to 4.9 mm HD and in *L. variegatus* from 8.8 to 18.1 mm HD. There are ten or more wedges in cross-sections of primary spines of *L. variegatus* at 5 mm HD and about seven wedges in those of *G. maculata*. The test is sculptured in *G. maculata* but not in *L. variegatus*.

ORDER ECHINOIDA CLAUS, 1876

One species belonging to this order has been collected in the Gulf of Mexico and an additional three species have been collected from nearby waters (Table 2).

KEY TO ECHINOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Aboral aspect round 2
1. Aboral aspect oval, longest axis passing through ambulacrum I and interambulacrum 3 3

2. Spines white to light brown; test green and white, forming a characteristic zig-zag pattern *Echinus gracilis* A. Agassiz
2. Spines pink to red; test white, with no zig-zag pattern *Echinus tyloides* H. L. Clark
3. Apical system with only one or two secondary tubercles on each genital and ocular plate; conspicuous white ring at base of each primary spine; pore-pairs in arcs of five (occasionally six) *Echinometra viridus* A. Agassiz
3. Apical system generally with five or more secondary tubercles on each genital and ocular plate; no white ring at base of primary spines; pore-pairs usually in arcs of six (rarely five or seven) *Echinometra lucunter* (Linné)

ORDER HOLECTYPOIDA DUNCAN, 1889

Only one species belonging to this order, *Echinoneus cyclostomus* Leske, is known from the Gulf of Mexico or from nearby waters (Table 2).

ORDER CLYPEASTEROIDA A. AGASSIZ, 1972

Ten species belonging to this order have been collected in the Gulf of Mexico, and four additional species have been collected from nearby waters (Table 2).

KEY TO CLYPEASTEROIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Lunules absent 2
1. Lunules present 11
2. Large forms up to 200 mm TL; petals distinct; ambulacral plates within petals pseudocompound (Figure 2m); genital pores not present in specimens less than 30 mm TL 3
2. Small forms, rarely larger than 15 mm TL; petals poorly developed; ambulacral plates within petal simple (Figure 2n); genital pores always present in specimens greater than 5 mm TL 10
3. Paired petals markedly open distally; distance between two inner pore-pairs at end of petal greater than 60 percent distance between inner pore-pairs at widest part of petal 4
3. Paired petals closed distally; above distance less than 60 percent 6
4. Test edge thickened, forming marginal ridge*Clypeaster ravenelii* (A. Agassiz)
4. Test edge not thickened 5

5. Distance between two inner pores of pore-pairs at distal end of petal slightly less than distance between two inner pores of pore-pair series at widest part of petal; test circular; ridge between pore-pairs with zero to three primary tubercles in adults *Clypeaster cyclopilus* H. L. Clark
5. Above distance equal to or greater than distance between any other pore-pairs of petal; test pentagonal, with interambulacral areas slightly indented in adults; test nearly circular in juveniles; ridge between pore-pairs with three to seven primary tubercles in adults *Clypeaster euclastus* H. L. Clark
6. Test high, without distinct flattened margin; aboral surface rising uniformly from ambitus to apex; oral side markedly concave *Clypeaster rosaceus* (Linné)
6. Test low, with distinct flattened margin; oral side flattened 7
7. Areoles of aboral primary tubercles within a circle described by distal ends of petals two to four times larger than those outside this area; ridge between pore-pairs of petals with zero to three primary tubercles in adults *Clypeaster lamprus* H. L. Clark
7. Areoles of aboral primary tubercles relatively uniform in size; ridge between pore-pairs of petals with six or more primary tubercles in adults 8
8. Test pentagonal; width at posterior edge of interambulacra 1 and 4 (Figure 2a) less than 91 percent of greatest TW; ridge between pore-pairs of petals with less than nine primary tubercles in adults (specimens greater than 120 mm TL with as many as 13 primary tubercles) *Clypeaster prostratus* Ravenel
8. Test oval; above width greater than 91 percent TW; ridge between pore-pairs of petals with nine or more primary tubercles in adults 9
9. Petaloid area longer than 50 percent TL in adults; test elongate, width less than 88 percent TL in specimens greater than 50 mm TL *Clypeaster subdepressus* (Gray)
9. Petaloid area less than 50 percent TL in adults; test oval, width greater than 88 percent TL *Clypeaster chesheri* Serafy
10. Ocular pores nearly as large as genital pores; petals relatively well developed *Echinocyamus grandiporus* Mortensen
10. Ocular pores much smaller than genital pores; petals relatively poorly developed *Echinocyamus macrostomus* Mortensen
11. Five or more lunules present 12
11. One lunule and two or more marginal notches present 13
12. Five lunules present; a line connecting tips of petals I and V passing through middle of posterior interambulacral lunule *Mellita quinquesperforata* (Leske)
12. Six lunules present; a line connecting tips of petals I and V marking adapical limit of posterior interambulacral lunule *Leodia sexiesperforata* (Leske)
13. Five distinct marginal notches, two posterior and three anterior; posterior interambulacral lunule long; peristome small (Figure 34) *Encope michelini* L. Agassiz
13. Two distinct posterior notches and three slight anterior indentations; posterior interambulacral lunule short; peristome large (Figure 34) *Encope aberrans* Martens

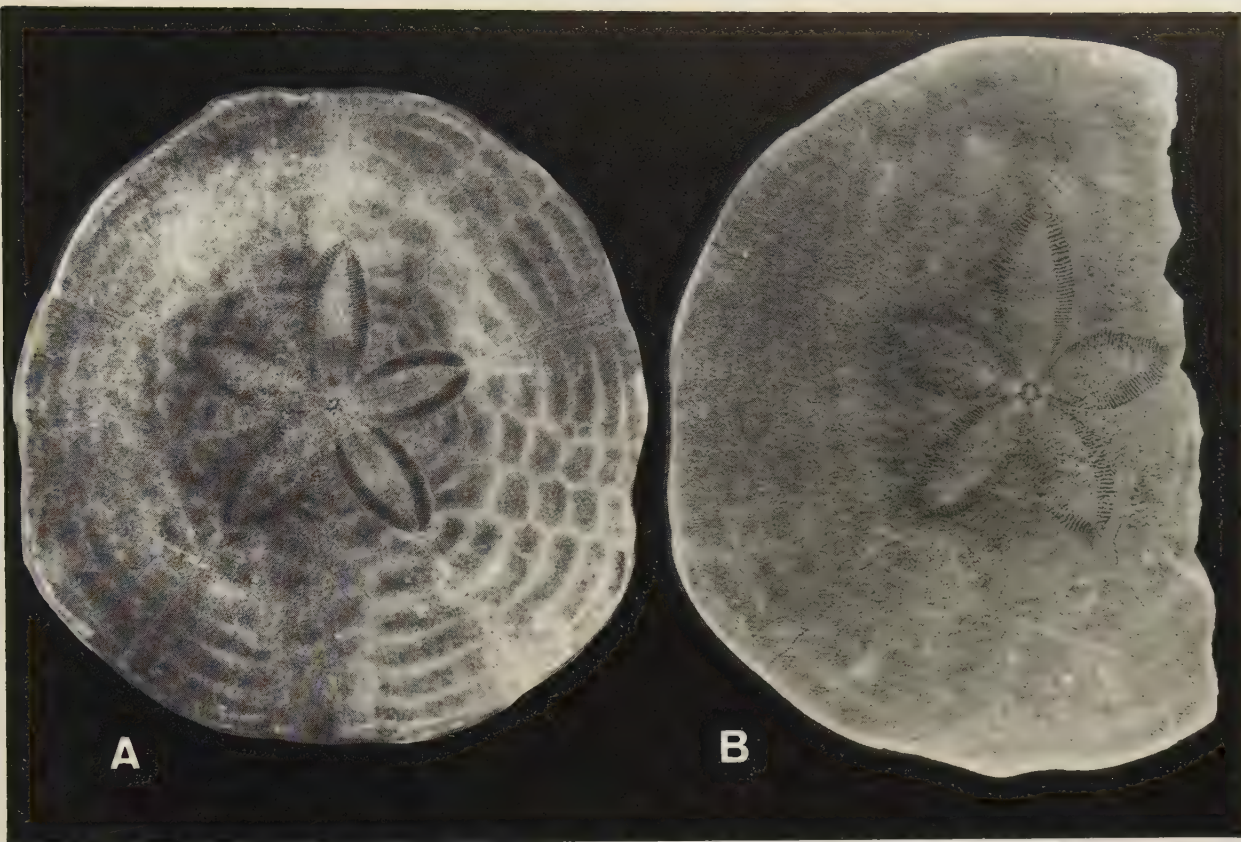


Figure 25. *Clypeaster chesheri*, aboral aspects: A, holotype, 184 mm TL; off Colombia, 37-33 m; USNM E10868; B, paratype, 106 mm TL; Station M, February 1967; FSBC I 4683.

Family Clypeasteridae L. Agassiz, 1835

Clypeaster chesheri Serafy, 1970

Figure 25

Clypeaster subdepressus: Mortensen, 1948b, pl. 23, fig. 1 [not *Clypeaster subdepressus* (Gray, 1825)].

Clypeaster chesheri Serafy, 1970, p. 663, text-figs. 1, 2c, 2d, 3-7.

Material examined: HOURGLASS STATION M: 2 (PARATYPES), 106.5, 160.0 mm; 16 February 1967; dredge; FSBC I 4683. — 3 (PARATYPES), 165.6-168.0 mm; 9 March 1967; dredge; FSBC I 4684. — OTHER MATERIAL: 1 (PARATYPE), 64.0 mm; 24 May 1965; off St. Petersburg, 27°25'N, 84°08'W; 64 m; FSBC I 4682. — 1 (PARATYPE), 83.1 mm; 12 April 1965; off Dry Tortugas, 24°25'N, 82°56'W; 62 m; USNM E10872. — 1 (PARATYPE), 33.1 mm; 1933; off Puerto Rico; USNM E3908. — 1 (PARATYPE), 99.0 mm; 21 March 1968; off Honduras, 15°57'N, 86°14'W; 46 m; USNM E10870. — 8 (PARATYPES), 63.5-110.0 mm; 21 March 1968; off Honduras, 15°58'N, 86°09'W; 35-40 m; USNM E10873. — 1 (PARATYPE), 156.0 mm; 20 July 1966; off Panama, 9°21'N, 80°14'W; 68-64 m; USNM E10867. — 1 (HOLOTYPE), 184.0 mm; 13 July 1966; off Colombia, 9°31'N, 76°00'W; 37-33 m; USNM E10868. — 1 (PARATYPE), 168.0 mm; 13 July 1966; off Colombia, 9°31'N, 76°00'W; 37-33 m; USNM E10864. — 1 (PARATYPE), 181.0 mm; 21 July 1966; off Colombia, 8°49.9'N, 81°22.1'W; 31 m; USNM E10865. — 1

(PARATYPE), 142.6 mm; 13 July 1966; off Colombia, 9°38'N, 75°50'W; 37 m; USNM E10866. — 3 (PARATYPES), 35.2-50.4 mm; 13-14 July 1966; off Colombia, 9°45'N, 76°12'W; 101-82 m; USNM E10869. — 3 (PARATYPES), 96.8-103.7 mm; 14 July 1966; off Colombia, 10°07'N, 75°48'W; 64-70 m; USNM E10871.

Diagnosis: Paired petals closed distally; oral side nearly flat, slightly concave around peristome; areoles of aboral primary tubercles relatively uniform in size; test oval; ridge between pore-pairs of petals with nine or more primary tubercles in adults; petaloid region less than 50 percent TL; TW greater than 88 percent TL.

Distribution: *Clypeaster chesheri* occurs from off St. Petersburg, Florida in the Gulf of Mexico, southward through the Greater and Lesser Antilles and along the Central and South American coasts from the Yucatan Peninsula to French Guiana (Serafy, 1970). It occurs in depths from 20 to 101 m.

Bottom type: Hourglass specimens occurred only at Station M, where bottoms were composed primarily of algal sand (*Lithothamnion* spp.).

Morphometric and meristic relationships: Five measurements and five counts were taken on 22 *C. chesheri* ranging from 33.1 to 184.0 mm TL. Three characters do not change with size (Table 12). Linear regression data for various characters as a function of TL are presented in Table 13.

TABLE 12. MERISTIC DATA FOR VARIOUS CHARACTERS THAT DO NOT CHANGE WITH SIZE
IN *C. CHESHERI*, *C. PROSTRATUS*, *C. RAVENELII* AND *C. SUBDEPRESSUS*.

Character	Species	Mean	Range	Standard Deviation
ABAM	<i>C. chesheri</i>	6.2	6-7	0.43
	<i>C. prostratus</i>	5.6	5-6	0.49
	<i>C. ravenelii</i>	5.9	5-7	0.51
	<i>C. subdepressus</i>	6.0	5-7	0.30
ORAM	<i>C. chesheri</i>	9.9	9-10	0.35
	<i>C. prostratus</i>	9.0	9-9	0.00
	<i>C. ravenelii</i>	10.1	10-11	0.36
	<i>C. subdepressus</i>	9.0	8-10	0.30
ORIA	<i>C. chesheri</i>	5.0	5-5	0.00
	<i>C. prostratus</i>	5.0	5-5	0.00
	<i>C. ravenelii</i>	5.0	5-5	0.00
	<i>C. subdepressus</i>	5.1	5-6	0.29

Clypeaster prostratus Ravenel, 1848

Figure 26

Clypeaster prostratus Ravenel, 1848, p. 3; H. L. Clark, 1914, p. 37; Mortensen, 1948b, p. 118, pl. 16, fig. 1, pl. 24, fig. 1, pl. 25, figs. 1, 2, pl. 26, fig. 5; A. H. Clark, 1954, p. 375; Serafy, 1970, p. 676.

Material examined: HOURGLASS STATION B: 2, 24.5, 30.1 mm; 11 September 1967; trawl; FSBC I 11042. — HOURGLASS STATION C: 1, 22.0 mm; 8 October 1966; trawl; FSBC I 4490. — 1, 12.5 mm; 8 October 1966; dredge; FSBC I 4495. — 1, 24.9 mm; 18 October 1966; trawl; FSBC I 4814. — fragments; 6 November 1966; trawl. — 1, 31.4 mm; 6 November 1966; dredge. — 2, 30.9, 38.5 mm; 3 April 1967; trawl. — 1, 25.0 mm; 11 May 1967; trawl. — 1, 21.1 mm; 11 May 1967; dredge; FSBC I 11038. — 1, 73.1 mm; 1

TABLE 13. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS AS A FUNCTION OF TL IN
C. CHESHERI, *C. PROSTRATUS*, *C. RAVENELII* AND *C. SUBDEPRESSUS**.

Character	Species	Regression Equation	$s_{y.x}$	r
TW	<i>C. chesheri</i>	$y = 0.93x + 0.21$	2.76	1.00
	<i>C. prostratus</i>	$y = 0.89x + 0.79$	2.71	1.00
	<i>C. ravenelii</i>	$y = 0.99x - 0.02$	0.79	1.00
	<i>C. subdepressus</i>	$y = 0.81x + 0.98$	4.09	0.99
TH	<i>C. chesheri</i>	$y = 0.10x + 2.47$	1.28	0.96
	<i>C. prostratus</i>	$y = 0.18x - 0.04$	1.72	0.98
	<i>C. ravenelii</i>	$y = 0.18x + 0.61$	0.71	0.97
	<i>C. subdepressus</i>	$y = 0.17x + 0.83$	1.68	0.98
PL	<i>C. chesheri</i>	$y = 0.22x - 1.62$	1.00	1.00
	<i>C. prostratus</i>	$y = 0.30x - 2.45$	1.79	0.99
	<i>C. ravenelii</i>	$y = 0.29x - 1.24$	0.82	0.99
	<i>C. subdepressus</i>	$y = 0.27x - 1.11$	1.24	0.99
OPW	<i>C. chesheri</i>	$y = 0.11x - 0.53$	0.92	0.98
	<i>C. prostratus</i>	$y = 0.16x - 1.94$	1.22	0.99
	<i>C. ravenelii</i>	$y = 0.12x - 0.42$	0.38	0.98
	<i>C. subdepressus</i>	$y = 0.15x - 0.43$	1.40	0.98
MIPW	<i>C. chesheri</i>	$y = 0.067x - 0.49$	0.64	0.98
	<i>C. prostratus</i>	$y = 0.079x - 0.41$	0.57	0.99
	<i>C. ravenelii</i>	$y = 0.060x + 0.08$	0.27	0.97
	<i>C. subdepressus</i>	$y = 0.085x - 0.19$	0.94	0.97
PAMB	<i>C. chesheri</i>	$y = 0.21x + 32.01$	5.37	0.87
	<i>C. prostratus</i>	$y = 0.15x + 12.29$	1.79	0.96
	<i>C. ravenelii</i>	$y = 0.19x + 8.76$	0.96	0.96
	<i>C. subdepressus</i>	$y = 0.19x + 9.94$	2.73	0.95
ABIA	<i>C. chesheri</i>	$y = 0.083x + 9.81$	1.20	0.95
	<i>C. prostratus</i>	$y = 0.079x + 9.90$	1.03	0.96
	<i>C. ravenelii</i>	$y = 0.082x + 7.96$	0.61	0.91
	<i>C. subdepressus</i>	$y = 0.103x + 8.94$	1.58	0.94

*All characters (ordinates) plotted as function of TL (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 22 for *C. chesheri*, 48 for *C. prostratus*, 27 for *C. ravenelii*, and 45 for *C. subdepressus*.

August 1967; trawl. — 2, 20.8, 45.3 mm; 5 October 1967; dredge. — 2, 53.2, 70.0 mm; 25 October 1967; dredge. — 12, 16.4-92.6 mm; 2 November 1967; trawl; FSBC I 6795. — 4, 10.4-74.3 mm; 2 November 1967; dredge; FSBC I 6763. — HOURGLASS STATION D: 1, 117.0 mm; 8 February 1966; dredge; FSBC I 1950. — 3, 93.6-154.0 mm; 4 March 1966; trawl; FSBC I 2741. — 1, 60.0 mm; 4 March 1966; dredge. — 5, 82.6-140.9 mm; 27 March 1966; trawl; FSBC I 2742. — 1, 21.0 mm; 11 July 1966; dredge; FSBC I 3420. — 2, 21.1, 38.3 mm; 2 August 1966; dredge; FSBC I 3607. — 2, 33.0, 89.0 mm; 1 September 1966; dredge. — 1, 119.0 mm; 9 September 1966; trawl. — 1, 50.0 mm; 9 September 1966; dredge. — 6, 8.8-51.6 mm; 9 October 1966; trawl; FSBC I 4565. — 2, 30.0, 45.0 mm; 9 October 1966; dredge. — 1, 68.7 mm; 20 November 1966; trawl. — 1, 73.7 mm; 2 December 1966; trawl. — 1, 47.0 mm; 7 January 1967; trawl. — 7, 64.5-148.3 mm; 7 January 1967; dredge. — 16, 64.0-159.0 mm; 21 January 1967; dredge; FSBC I 6800. — 1, 68.5 mm; 26 January 1967; trawl. — 1, 74.4 mm; 6 February 1967; dredge. — 2, 62.1, 86.2 mm, 1 dead test; 15 March 1967; dredge. — 2, 39.3, 125.0 mm, 1 dead test, 103.9 mm; 4 April 1967; dredge. — 2,



Figure 26. *Clypeaster prostratus*, aboral aspect, 93 mm TL; Station D, March 1966; FSBC I 2741.

18.0, 19.4 mm; 12 May 1967; trawl. — 2, 27.9, 63.9 mm; 3 June 1967; dredge; FSBC I 11040. — 2, 40.0, 46.1 mm; 21 June 1967; dredge. — 2, 19.1, 27.5 mm; 2 July 1967; trawl. — 1, 76.5 mm; 2 July 1967; dredge. — 1, 14.9 mm; 2 August 1967; trawl. — 2, 53.9, 62.4 mm; 6 October 1967; trawl. — 1, 70.0 mm; 6 October 1967; dredge. — 4, 77.3-102.4 mm; 27 October 1967; dredge. — 7, 23.4-88.8 mm; 3 November 1967; trawl; FSBC I 6764. — 1, 35.5 mm; 3 November 1967; dredge. — HOURGLASS STATION E: 1, 25.0 mm; 12 May 1967; trawl; FSBC I 11039. — HOURGLASS STATION K: 1, 27.0 mm; 4 September 1966; trawl. — 1, 29.0 mm; 4 September 1966; dredge. — 1, 17.6 mm; 12 October 1966; trawl; FSBC I 4726. — 1, 40.8 mm; 12 October 1966; dredge; FSBC I 4729. — 1, 23.7 mm; 6 December 1966; trawl. — 1, 80.0 mm; 15 February 1967; dredge. — 2, 25.4, 40.8 mm; 7 August 1967; trawl. — 3, 10.5-93.0 mm; 4 September 1967; trawl. — 2, 31.1, 45.9 mm; 11 October 1967; trawl; FSBC I 11043. — 1, 90.0 mm; 11 October 1967; dredge; FSBC I 11044. — 3, 31.4-45.1 mm; 14 November 1967; dredge; FSBC I 11045. — HOURGLASS STATION L: 1, 41.3 mm; 13 June 1966; dredge; FSBC I 3124. — 1, 30.0 mm; 6 July 1966; dredge. — 2, 28.9, 40.5 mm; 6 July 1966; trawl; FSBC I 3096. — 2, 16.0, 70.8 mm; 5 September 1966; trawl; FSBC I 4014. — 2, 18.8, 53.8 mm; 13 October 1966; trawl; FSBC I 4740. — 1, 18.5 mm; 13 November 1966; trawl. — 3, 69.5-82.0 mm; 13 January 1967; trawl. — 2, 25.1, 137.7 mm; 6 July 1967; dredge; FSBC I 11041. — 2, 25.1, 26.0 mm; 8 August 1967; trawl. — 2, 42.0, 48.0 mm; 2 September 1967; trawl. — 1, 66.0 mm; 15 November 1967; trawl. — HOURGLASS STATION M: 1, 60.8 mm; 15 November 1967; trawl; FSBC I 11046.

Diagnosis: Paired petals closed distally; oral side nearly flat, slightly concave around peristome; test pentagonal; ridge between pore-pairs of petals with 6-8 primary tubercles in adults (unusually large specimens, greater than 120 mm TL, with up to 13 primary tubercles); usually 15 ambulacral plates outside petals II and IV.

Distribution: *Clypeaster prostratus* is known from North Carolina, southward around the tip of Florida to Pensacola and off the Yucatan Peninsula in the Gulf. In the Caribbean, it is known from Antigua and the coasts of Panama, Colombia and Venezuela. It occurs from 15 to 75 m.

Bottom type: Hourglass specimens occurred most frequently on bottoms of algal sand (*Lithothamnion* spp.) and crushed shell at Stations C, D, K and L (Table 14).

Population dynamics: In 1965, Station D was the only station with a population of *C. prostratus*. In 1966, Stations C, D, K and L had recruitment of juveniles, but only Station D had large adults (100 to 160 mm TL). In 1967, recruitment occurred at Stations B, C, D, E, K, L and M, but by this time all large adults at Station D had disappeared, leaving only the recruits believed to be from the 1966 and 1967 year classes.

Morphometric and meristic relationships: Five measurements and five counts were taken on 48 *C. prostratus* from 10 to 160 mm TL. Three meristic characters do not change with growth (Table 12). This agrees with conclusions of Durham (1955) that numbers of oral ambulacral and interambulacral plates and number of aboral ambulacral plates outside the petals do not change with increasing size. Linear regression data for various characters as a function of TL are presented in Table 13.

TABLE 14. NUMBERS OF *CLYPEASTER PROSTRATUS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Clypeaster prostratus																															
STA	1965					1966												1967											TOT		
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S		O	N
A																															
B ₁																															
B ₂																												2			2
C ₁																	2	1					2	2			1		2	16	26
C ₂																1													2		3
D ₁						1	4						2		2	8		1	8	1	1		2	2	2	3	1		3	8	49
D ₂							5					1			2		1		16			2			2				4		33
E																								1							1
I																															
J																															
K															2	2		1			1						2	3	3	3	17
L											1	3			2	2	1		3							2	2	2		1	19
M																														1	1
TOT						1	9				1	4	2		8	15	3	2	27	1	2	2	4	5	4	5	6	7	14	29	151

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Clypeaster ravenelii (A. Agassiz, 1869)

Figure 27

Stonoclypus ravenelii A. Agassiz, 1869, p. 265.

Clypeaster ravenelii: A. Agassiz, 1883, p. 43, pl. 15b, figs. 1, 2, pl. 15c, figs. 1, 2; Rathbun, 1885, p. 614; 1886, p. 281; H. L. Clark, 1914, p. 27, pl. 122, figs. 12-14, pl. 123, figs. 5-10; Mortensen, 1948b, p. 49, pl. 5, figs. 1-4, pl. 64, figs. 7, 9, 13, 18; A. H. Clark, 1954, p. 375; Hildebrand, 1954, p. 278; Serafy, 1970, p. 675; Burke, 1974, p. 315, fig. 4.



Figure 27. *Clypeaster ravenelii*, aboral aspect, 71 mm TL; Station M, September 1967; USNM E15225.

Material examined: HOURGLASS STATION D: 1, 15.3 mm; 9 October 1966; trawl; FSBC I 4564. — 2, 49.0, 49.3 mm; 4 April 1967; dredge; FSBC I 6786. — HOURGLASS STATION E: 1, 55.0 mm; 4 December 1965; dredge. — 1, 62.4 mm; 8 February 1966; trawl; FSBC I 1961. — 1, 44.5 mm; 3 July 1966; dredge; FSBC I 3087. — 1, 38.7 mm; 1 September 1966; dredge; FSBC I 3993. — 2, 41.3, 51.8 mm; 12 May 1967; dredge. — 1, 80.1 mm; 2 July 1967; dredge; FSBC I 6765. — 1, 36.4 mm; 2 August 1967; trawl. — 1, 26.0 mm; 6 October 1967; trawl; FSBC I 6772. — HOURGLASS STATION M: 2, 35.6, 57.8 mm; 6 July 1966; trawl; FSBC I 3174. — 5, 30.3-41.6 mm; 6 July 1966; dredge; FSBC I 3184. — 1, 20.9 mm; 13 January 1967; trawl. — 3, 43.7-45.9 mm; 16 February 1967; dredge; FSBC I 4685. — 1, 66.1 mm; 9 March 1967; trawl. — 3, 55.0-76.8 mm; 9 March 1967; dredge. — 1, 71.2 mm; 5 September 1967; dredge. — 1, 56.0 mm; 15 November 1967; dredge.

Diagnosis: Paired petals open distally; oral side nearly flat, slightly concave around peristome; test pentagonal, sides distinctly indented; test edge thickened into marginal ridge; ridge between pore-pairs of petals with 2-6 primary tubercles in adults; usually 16 ambulacral plates outside petals II and IV.

Distribution: *Clypeaster ravenelii* is known from Cape Hatteras, North Carolina southward through the Greater and Lesser Antilles to Grenada. In the Gulf of Mexico, the species is known from off the west coast of Florida to the Flower Gardens off Texas and from the Campeche Banks off Yucatan. It occurs from 50 to 230 m.

Bottom type: Hourglass specimens were collected on bottoms of algal sand (*Lithothamnion* spp.) at Stations D, E and M (Table 15).

TABLE 15. NUMBERS OF *CLYPEASTER RAVENELII* COLLECTED DURING PROJECT
HOURGLASS, BY STATION AND MONTH.

Clypeaster ravenelii																																				
STA	1965					1966																	1967										TOT			
	A	S	O	N	D	J	F	M	A	M	J	J	J	sp	A	S	O	N	D	J	J	sp	F	M	A	M	J	J	A	S	O	N				
A																																				
B ₁																																				
B ₂																																				
C ₁																																				
C ₂																																				
D ₁																	1									2							3			
D ₂																																				
E					1		1					1			1											2		1	1		1		9			
I																																				
J																																				
K																																				
L																																				
M												7								1		3	4						1		1	17				
TOT					1		1					8				1	1			1		3	4	2	2		1	1	1	1	1	29				

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Morphometric and meristic relationships: Five measurements and five counts were taken on 27 specimens ranging from 16 to 80 mm TL. Three meristic characters do not change with size (Table 12). Linear regression data for various characters as a function of TL are presented in Table 13.

Clypeaster subdepressus (Gray, 1825)

Figure 28

Echinanthus subdepressus Gray, 1825, p. 427.

Clypeaster subdepressus: A. Agassiz, 1883, p. 43, pl. 15a, figs. 1-4; Rathbun, 1885, p. 615; Jackson, 1912, p. 196, text-figs. 231, 232; H. L. Clark, 1914, pp. 24, 38, pl. 123, figs. 11, 12; 1918, p. 36; 1933, p. 86; Tortonese, 1933, p. 142; Mortensen, 1948b, p. 112, pl. 23, figs. 2, 3, pl. 24, fig. 3, pl. 25, fig. 6, pl. 26, figs. 1, 6, pl. 27, fig. 4, pl. 65, figs. 4, 11, 14, 15; Mayr, 1954, p. 11; Hildebrand, 1955, p. 196; Kier and Grant, 1965, p. 28, pl. 5, figs. 1-6, 8, pl. 6, figs. 1-10, pl. 15, fig. 8; Kier, 1966, p. 7; Tommasi, 1966b, p. 24, text-figs. 41-44, pl. 7b; Serafy, 1970, p. 672, text-figs. 2a, 2b; Menzel, 1971, p. 86; Chesher, 1972, p. 151; Jolley, 1972, p. 37; Godcharles and Jaap, 1973, p. 52.

not *Clypeaster subdepressus*: Mortensen, 1948b, pl. 23, fig. 1 [= *C. chesheri* Serafy, 1970].

Material examined: HOURGLASS STATION B: 1, 89.0 mm; 2 July 1966; dredge. — 2, 90.0, 115.0 mm; 1 August 1966; dredge. — 2, 128.4, 130.0 mm; 2 March 1967; dredge; FSBC I 6762. — 1, 3.4 mm; 2 June 1967; dredge; FSBC I 11049. — 1, 122.0 mm; 5 October 1967; dredge. — 1, 99.0 mm; 2 November 1967; dredge; FSBC I 6785. — HOURGLASS STATION C: 1, 50.8 mm; 5 October 1965; trawl; FSBC I 911. — 1, 121.2 mm; 3 January 1966; dredge; FSBC I 1571. — 1, 113.0 mm; 6 April 1966; dredge. — 2, 112.4, 116.9 mm; 2 May 1966; trawl. — 2, 101.0, 115.0 mm; 2 May 1966; dredge. — 4, 112.4-116.0 mm; 8 October 1966; dredge. — 1, 26.6 mm; 19 November 1966; dredge; FSBC I 11047. — 2, 107.4 mm, adult fragments; 13 December 1966; dredge. — 1, 38.9 mm; 6 January 1967; trawl. — 1, 118.3 mm; 6 January 1967; dredge; FSBC I 6783. — 3, 116.6-125.0 mm; 5 February 1967; dredge; FSBC I 6784. — 3, 12.0-116.6 mm; 2 June 1967; dredge; FSBC I 5861. — 1, 109.4 mm; 31 August 1967; trawl. — 1, 111.0 mm; 5 October 1967; dredge. — 1, 21.9 mm; 2 November 1967; trawl. — HOURGLASS STATION D: 1, 190.2 mm; 4 December 1965; dredge; FSBC I 1376. — HOURGLASS STATION I: 3, 134.0-157.0 mm; 21 March 1966; dredge. — 1 dead test, 144.0 mm; 11 October 1967; trawl; FSBC I 11108. — HOURGLASS STATION J: 1, 29.1 mm; 6 December 1965; trawl; FSBC I 1430. — HOURGLASS STATION K: 1, 128.6 mm; 6 December 1965; dredge; FSBC I 1443. — 1, 20.5 mm; 13 January 1966; trawl; FSBC I 1665. — 16,



Figure 28. *Clypeaster subdepressus*, aboral aspects: A, 116 mm TL; data unknown; B, partially cleaned, 116 mm TL; Station C, February 1967; FSBC I 6784.

100.5-151.0 mm; 14 February 1966; dredge; FSBC I 2045. — 1, 105.0 mm; 21 March 1966; trawl. — 4, 32.0-143.0 mm; 12 June 1966; dredge. — 1, 19.2 mm; 5 August 1966; trawl; FSBC I 3774. — 1, 130.0 mm; 5 August 1966; dredge. — 4, 127.0-149.0 mm; 4 September 1966; dredge. — 1, 27.2 mm; 4 September 1966; trawl; FSBC I 4018. — 2, 98.5, 121.7 mm; 12 November 1966; dredge. — dead test fragment; 6 December 1966; dredge. — 2, 24.2, 144.0 mm; 12 January 1967; dredge. — 1, 43.3 mm; 15 February 1967; trawl; FSBC I 5863. — 2, 127.5, 147.0 mm; 8 March 1967; dredge. — 2, 40.4, 60.0 mm; 7 April 1967; trawl; FSBC I 5864. — 1, 62.0 mm, 1 dead test, 116.3 mm; 7 April 1967; dredge. — 1 dead test, 125.8 mm; 6 June 1967; dredge. — 4, 11.9-72.4 mm; trawl; FSBC I 5862. — HOURGLASS STATION L: 1, 190.0 mm; 6 July 1967; dredge; FSBC I 11048.

Diagnosis: Paired petals closed distally; oral side nearly flat, slightly concave around peristome; test oval; ridge between pore-pairs of petals with nine or more tubercles in adults; usually 15 ambulacral plates outside petals II and IV.

Distribution: *Clypeaster subdepressus* is known from North Carolina southward through the Greater and Lesser Antilles. It is known in the Gulf of Mexico from St. Petersburg, Florida and Campeche Banks southward along the coasts of Central and South America to Rio de Janeiro, Brazil. It occurs in depths from 5 to 210 m, but is most common in less than 50 m.

TABLE 16. NUMBERS OF *CLYPEASTER SUBDEPRESSUS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Clypeaster subdepressus																																		
STA	1965					1966												1967												TOT				
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O		N			
A																																		
B ₁												1		2								2				1			1	1				
B ₂																																		
C ₁			1			1			1	4							4		2		3				3			1	1	1				
C ₂																																		
D ₁					1												1	2																
D ₂																																		
E																																		
I									3																									
J					1																													
K					1	1	16	1				4			2	5		2		2		1	2	3				4						
L																																		
M																											1							
TOT			1		3	2	16	4	1	4	4	1		4	5	4	3	2	4		4	4	3		4	1	4	1	2	2				

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Bottom type: In the Florida Keys, *C. subdepressus* occurs on sand bottoms with little or no seagrass (Kier and Grant, 1965), thus enabling them to burrow. Hourglass specimens occurred most frequently on crushed shell bottoms at Stations C and K (Table 16).

Morphometric and meristic relationships: Five measurements and five counts were taken on 45 *C. subdepressus* ranging from 19 to 190 mm TL. Three characters do not change with size (Table 12). Linear regression data for various characters as a function of TL are presented in Table 13.

Clypeaster spp.

Material examined: HOURGLASS STATION B: 1, 5.5 mm; 11 September 1967; trawl; FSBC I 11060. — 1, 3.5 mm; 11 September 1967; dredge; FSBC I 11061. — 1, 4.4 mm; 5 October 1967; dredge; FSBC I 11062. — 1 dead test, 2.1 mm; 2 November 1967; dredge; FSBC I 11063. — HOURGLASS STATION C: 1, 3.3 mm; 2 March 1967; dredge; FSBC I 11051. — 1, 2.8 mm; 2 June 1967; trawl; FSBC I 11054. — 13, 1.8-3.5 mm; 2 June 1967; dredge; FSBC I 6769. — 1, 3.8 mm; 1 July 1967; dredge; FSBC I 11055. — 5, 2.2-9.1 mm; 11 July 1967; dredge; FSBC I 11057. — 2, 3.2, 6.6 mm; 31 August 1967; trawl; FSBC I 11058. — 1, 4.7 mm; 2 November 1967; trawl; FSBC I 11064. — HOURGLASS STATION K: 1, 8.3 mm; 4 September 1967; dredge; FSBC I 11059. — HOURGLASS STATION L: 3, 2.2-2.9 mm; 5 September 1966; dredge; FSBC I 4108. — 1, 5.0 mm; 13 November 1966; dredge; FSBC I 11050. — 1, 5.0 mm; 9 March 1967; trawl; FSBC I 11052. — 1, 5.8 mm; 8 April 1967; dredge; FSBC I 11053. — 1, 6.8 mm; 6 July 1967; dredge; FSBC I 11056. — HOURGLASS STATION M: 2, 3.5, 3.6 mm; 5 September 1966; dredge; FSBC I 4546.

Remarks: Specific determinations were seldom made of juvenile specimens of *Clypeaster* less than about 10 mm TL.

Randall (1967) found specimens of *Clypeaster* sp. in stomach contents of the margate, *Haemulon album*.

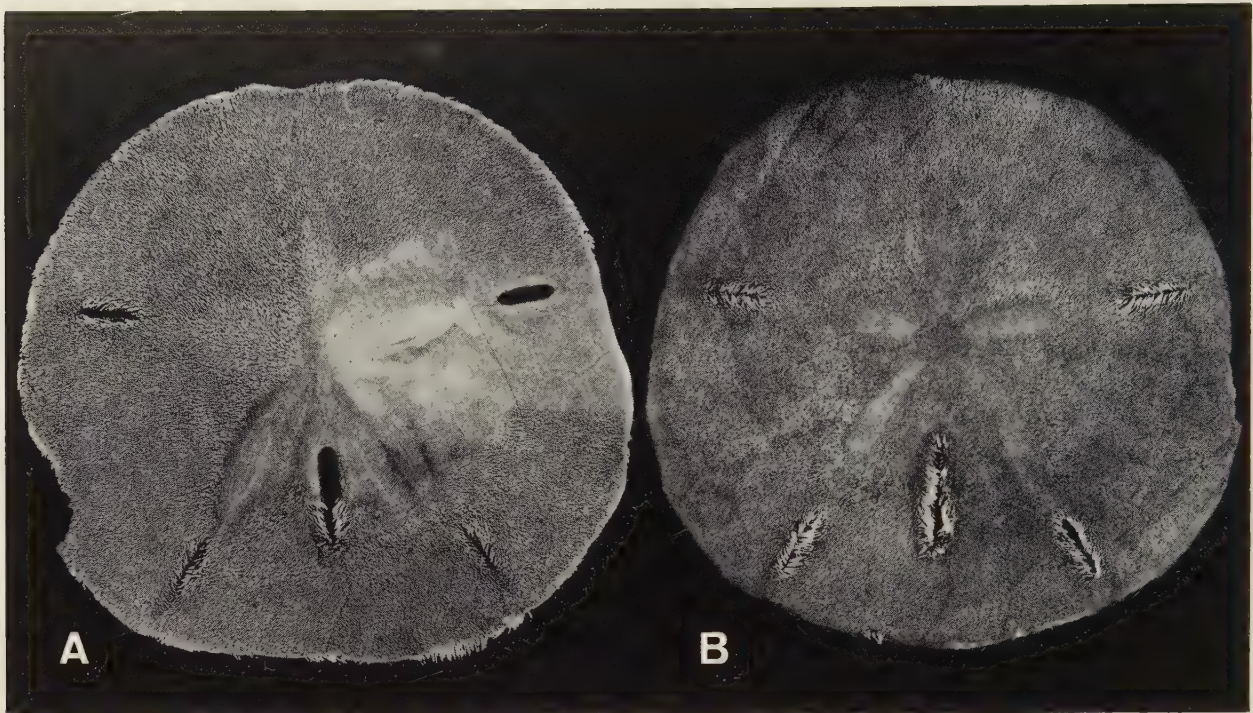


Figure 29. *Mellita quinquesperforata*, aboral aspects: A, partially cleaned, 90 mm TL; Station I, January 1966; FSBC I 1628; B, 87 mm TL; Station A, October 1965; FSBC I 898.

Family Mellitidae Stefanini, 1911

Mellita quinquesperforata (Leske, 1778)

Figure 29

Echinodiscus quinquesperforatus Leske, 1778, p. 197, pl. 21, figs. C, D.

Echinus pentaporus Gmelin, 1788, p. 3189.

Mellita testudinata L. Agassiz, 1841, p. 40; A. Agassiz, 1869, p. 266; 1872, p. 322, pl. 11, figs. 13-22, pl. 12a, pl. 12c, figs. 1, 2; Rathbun, 1886, p. 285; H. L. Clark, 1901b, p. 254; Cary, 1906, p. 52.

Mellita ampla Ravenel, 1848, p. 2.

Mellita pentapora: Ives, 1890, p. 328; H. L. Clark, 1904, p. 565; Coe, 1912, p. 112, pl. 24, fig. 1, pl. 28.

Mellita quinquesperforata: H. L. Clark, 1914, p. 76, pl. 125, figs. 16-21; 1933, p. 87; Tortonese, 1933, p. 154; H. L. Clark, 1942, p. 381; Caso, 1946, p. 247, text-figs. 1, 2; Mortensen, 1948b, p. 422, pl. 62, fig. 3, pl. 72, fig. 16; Behre, 1950, p. 10; Gunter, 1950, p. 39; Hildebrand, 1954, p. 278; A. H. Clark, 1954, p. 375; Mayr, 1954, p. 5; Hutton et al., 1956, p. 57; Parker, 1956, p. 337, figs. 23a, 27a, pl. 6, fig. 14b; Hyman, 1958, p. 54; Richmond, 1962, p. 91; Cerame-Vivas and Gray, 1964, p. 303; Dragovich and Kelly, 1964, p. 93; Salsman and Tolbert, 1965, p. 152; Tommasi, 1966b, p. 25, text-figs. 45-48, pl. 6a; Stokes et al., 1968, p. 16; Weihe and Gray, 1968, p. 315; Bell and Frey, 1969, p. 553; Godcharles, 1971, p. 28; Lyons et al., 1971, p. 38; Menzel, 1971, p. 86; Jolley, 1972, p. 37; Moss and Lawrence, 1972, p. 225; Godcharles and Jaap, 1973, p. 53.

Mellita lata H. L. Clark, 1940, p. 437, pl. 60, fig. 1, pl. 61, fig. 1, pl. 62, figs. 1, 2; Kenk, 1944, p. 177, figs. 2, 4; Caso, 1946, p. 251, figs. 3-6.

Material examined: HOURGLASS STATION A: 3, 63.4-86.3 mm; 3 August 1965; trawl; FSBC I 636. — 23, 59.0-101.0 mm; 3 August 1965; dredge; FSBC I 647. — 318 adults; 30 August 1965; dredge. — 117, 21.0-88.0 mm; 30 August 1965; trawl. — 35, 26.1-88.0 mm; 4 October 1965; trawl; FSBC I 898. — 200 adults; 4 October 1965; dredge. — 11, 77.0-108.0 mm; 8 November 1965; dredge. — 56, 51.0-98.0 mm; 8 November 1965; trawl. — 444, 21.0-81.0 mm; 3 December 1965; trawl; FSBC I 1323. — 517, 68.0-92.0 mm; 3 December 1965; dredge; FSBC I 1328. — 5230, 21.0-86.0 mm; 3 January 1966; trawl; FSBC I 1500. — 1590, 62.0-100.0 mm; 3 January 1966; dredge; FSBC I 1502. — 339, 55.0-101.0 mm; 5 February 1966; dredge. — 69, 57.0-81.0 mm; 5 February 1966; trawl. — 5591, 23.0-97.0 mm; 7 February 1966; trawl. — 536 juveniles and adults; 7 February 1966; dredge. — 1025, 33.0-71.0 mm; 3 March 1966; trawl. — 3160, 31.0-83.0 mm; 6 April 1966; trawl. — 92, 51.0-97.0 mm; 6 April 1966; dredge. — 3166, 28.0-79.0 mm; 2 May 1966; trawl. — 400 adults; 2 May 1966; dredge. — 3293, 32.0-87.0 mm; 6 June 1966; trawl. — 35, 48.0-94.0 mm; 6 June 1966; dredge. — 1054, 34.0-85.0 mm; 2 July 1966; trawl. — 2137, 48.0-99.0 mm; 2 July 1966; dredge. — 1, 58.0 mm; 18 July 1966; trawl. — 210, 42.0-83.0 mm; 1 August 1966; trawl. — 875, 68.0-100.0 mm; 1 August 1966; dredge. — 78, 43.0-93.0 mm; 31 August 1966; trawl. — 872, 54.0-96.0 mm; 31 August 1966; dredge. — 20, 47.0-67.0 mm; 8 October 1966; trawl. — 5, 69.0-105.0 mm; 8 October 1966; dredge. — 175, 39.0-75.0 mm; 6 November 1966; trawl. — 575, 59.0-97.0 mm; 6 November 1966; dredge. — 857, 61.1-72.5 mm; 1 December 1966; trawl. — 113, 61.0-102.0 mm; 1 December 1966; dredge. — 13, 100.0-104.0 mm; 6 January 1967; dredge. — 69, 52.0-73.0 mm; 2 March 1967; trawl. — 769, 67.0-106.0 mm; 2 March 1967; dredge. — 3, 82.9-91.5 mm; 3 April 1967; trawl; FSBC I 6781. — 1838, 63.0-95.0 mm; 3 April 1967; dredge. — 506, 45.0-77.0 mm; 11 May 1967; trawl. — 104, 57.0-99.0 mm; 11 May 1967; dredge. — 61, 72.0-104.0 mm; 2 June 1967; dredge. — 242, 14.4-103.0 mm; 1 July 1967; dredge. — 40, 56.0-82.0 mm; 1 July 1967; trawl. — 23, 72.0-106.0 mm; 1 August 1967; dredge. — 5, 53.6-68.6 mm; 1 August 1967; trawl. — 201, 53.0-83.0 mm; 31 August 1967; trawl. — 79, 66.0-117.0 mm; 31 August 1967; dredge. — 3, 62.1-67.0 mm, 1 dead test, 66.4 mm; 5 October 1967; trawl. — 3, 72.5-87.0 mm, 4 dead tests, 74.0-81.4 mm; 5 October 1967; dredge. — 85, 40.0-91.0 mm; 2 November 1967; trawl. — 341, 37.0-97.0 mm; 2 November 1967; dredge. — HOURGLASS STATION B: 1 adult; 3 August 1965; trawl. — 1 adult; 30 August 1965; trawl. — 2, 28.8, 72.8 mm; 3 January 1966; trawl. — 2, 40.0, 75.0 mm; 7 February 1966; trawl. — 7, 39.0-74.0 mm; 3 March 1966; trawl. — 3, 41.0-71.0 mm; 6 April 1966; trawl. — 2, both 68.0 mm; 2 May 1966; trawl. — 2, 49.0, 68.0 mm; 6 June 1966; trawl. — 1, 25.0 mm; 17 June 1966; trawl. — 1, 52.0 mm; 2 July 1966; trawl. — 1, 72.0 mm; 1 August 1966; trawl. — 1, 67.0 mm; 31 August 1966; trawl. — 3, 54.2-76.2 mm; 25 January 1967; trawl. — 1 adult; 5 February 1967; trawl. — 1 adult; 2 March 1967; trawl. — 2, 56.6, 65.9 mm; 11 May 1967; trawl. — 1, 56.9 mm; 31 August 1967; trawl. — HOURGLASS STATION C: 1, 43.0 mm; 3 March 1966; trawl. — HOURGLASS STATION I: 4, 77.8-94.5 mm; 13 January 1966; trawl; FSBC I 1628. — 52, 78.0-105.0 mm; 11 May 1966; trawl. — 38, 14.7-34.1 mm; 7 August 1967; trawl.

Diagnosis: One interambulacral and four ambulacral lunules present; an imaginary line between tips of petals I and V passes through middle of posterior interambulacral lunule; four genital pores.

Distribution: *Mellita quinquesperforata* occurs from Cape Cod, Massachusetts southward along the Atlantic and Gulf coasts, throughout the Greater and Lesser Antilles, and along the Central and South American coasts to São Paulo, Brazil. It occurs in depths from 0 to 180 m but is most commonly found in less than 30 m.

Bottom type: The species usually occurs on sand substrates of estuaries and inshore environments, generally on the sediment surface or slightly covered by a few centimeters of sand. Weihe and Gray (1968) report that it can burrow down to 20 to 25 cm during storms. Of the 37,739 specimens collected in this study (Table 17), over 99.7 percent (37,612) were collected at Station A, while only 94 specimens were collected at Station I,

TABLE 17. NUMBERS OF *MELLITA QUINQUIESPERFORATA* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Mellita quinquesperforata																															
STA	1965					1966															1967										TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A	26	435	235	67	961	6820	6127	1030	3252	3566	3328	3191	1	1085	950	25	750	970	13		408	838	1841	610	61	282	28	280	6	426	37612
B ₁	1	1				2	2	7	3	2	2	1		1	1					3	1	1		2				1			31
B ₂											1																				1
C ₁								1																							1
C ₂																															
D ₁																															
D ₂																															
E																															
I						4				52																	38				94
J																															
K																															
L																															
M																															
TOT	27	436	235	67	961	6826	6129	1038	3255	3620	3331	3192	1	1086	951	25	750	970	13	3	409	839	1841	612	61	282	66	281	6	426	37739

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

the inshore sand station of the southern transect. This can possibly be explained by the fact that sediments at Station A are well sorted, fine quartz sand with a modal grain size of 0.18 mm while sediments at Station I consist of crushed shell and poorly sorted quartz sand with a larger modal grain size of 0.6 mm. Other authors report modal grain sizes varying from 0.2 to 0.4 mm in areas where *M. quinquesperforata* is abundant (Hyman, 1958; McNulty et al., 1962; Weihe and Gray, 1968).

Diet: Microscopic examination of gut contents by Moss and Lawrence (1972) showed that detritus, diatoms, dinoflagellates, sponge spicules and fine sand were the major components. According to Bell and Frey (1969), food particles are moved along the food grooves to the mouth by the accessory tube feet.

Growth and reproduction: Size frequency was plotted for *M. quinquesperforata* collected during the last 12 months of the study (Figure 30). Prior to the last year, specimens were often counted and discarded due to lack of storage space. Numbers for each month in Figure 30 cannot be considered representative of the size of each monthly catch, since they are inconsistent aliquot samples. They only indicate the number of specimens returned to the laboratory to be measured. For example, only 43 specimens were returned in April 1967 out of 1841 specimens collected. In the following month, 506 specimens were returned to the laboratory of a total 610 specimens collected by the same unit effort. However, the plots can be used to distinguish year classes. There appears to be a mode between 50 and 75 mm TL throughout most of the year and another between 80 and 100 mm TL. These data compare with unpublished results of growth studies conducted by Jacqueline Moss (personal communication) at St. Petersburg, Florida.

In July 1967, a group of juveniles with a mean TL of 19 mm were collected. Specimens presumably representing the same young-of-the-year had a mean TL of 45 mm by November 1967. If this growth curve is extrapolated to its origin, time of metamorphosis is calculated to be early April. According to J. W. Caldwell (personal communication), the normal larval life of *M. quinquesperforata* in the Gulf is seven to nine days. If this is correct, spawning would have occurred sometime in late March 1967. This agrees with Moss and Lawrence (1972), who report that *M. quinquesperforata* spawns from February to April near St. Petersburg. Thus, specimens between 50 and 75 mm TL in March 1967 probably represent specimens one year old, and specimens between 80 and 100 mm TL represent specimens two or more years old.

Recruitment appears to have been earlier and greater in 1966 (January) than in 1967 (March-April) (Figure 31).

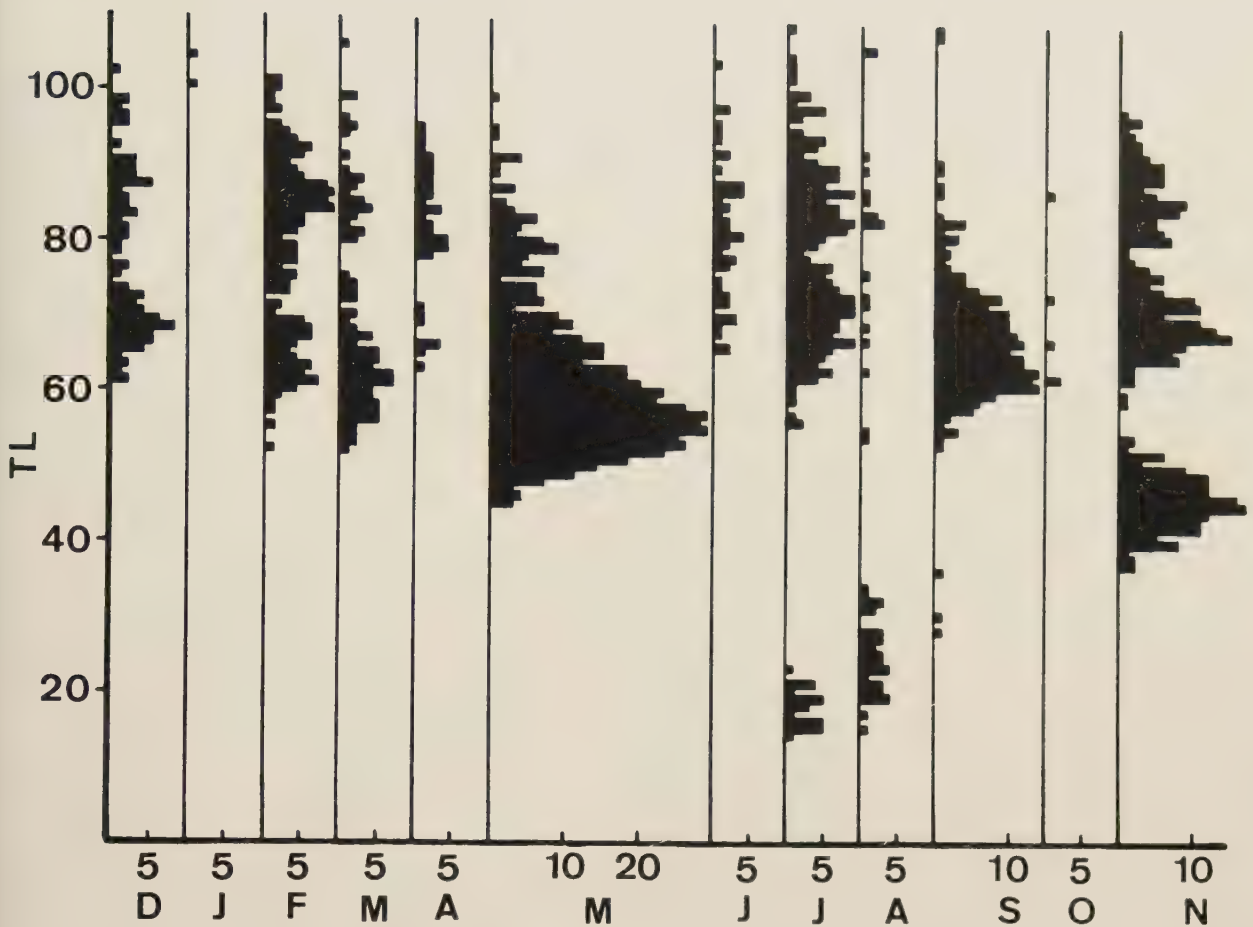


Figure 30. Size frequency plots for *M. quinquesperforata*, Station A, December 1966–November 1967.

Genital pores developed in specimens between 19 and 44 mm TL.

Population dynamics: *Mellita quinquesperforata* is extremely abundant on inshore sandy bottoms (Parker, 1956; Moore, 1965; Salsman and Tolbert, 1965; Weihe and Gray, 1968; Moss and Lawrence, 1972). Concentrations up to 74/30 cm² ($\cong 246/\text{m}^2$) have been reported by Salsman and Tolbert (1965) off Panama City, Florida. Although the geographic range is extensive, it is generally restricted to a narrow depth band along the coast. Salsman and Tolbert (1965) found that densities increased from the surf zone to the 7 m contour. Densities then began decreasing until the species disappeared at the 15 m depth contour off Panama City, where it was replaced by *Encope*. Similar results are seen (Table 17) for Hourglass specimens along the northern transect, with 37,612 specimens collected at Station A (6 m), 32 specimens collected at Station B (18 m), and only one specimen collected at Station C (37 m). The only specimens collected along the southern transect were 94 in three trynet collections at Station I (6 m). As discussed above, this was probably a result of the coarse grain size found at Station I. Mass mortalities in August were described by Salsman and Tolbert (1965) for *M. quinquesperforata* off Panama City, Florida; they speculated that mass mortalities may occur annually. Moss and Lawrence (1972) noted similar mortalities off St. Petersburg, Florida; they believed the mortalities resulted from starvation when summer energy demands exceeded nutrient storage capacity, particularly in large adults. Similar decreases in numbers of *M. quinquesperforata* are evident during August 1966 and June 1967 of the present study (Figure 31).

Kenk (1944) recorded short-term movement rates of 11 to 26 mm/min, and Weihe and Gray (1968) recorded an average rate of 14.6 mm/min. As soon as animals were covered with a thin layer of sand, the rate

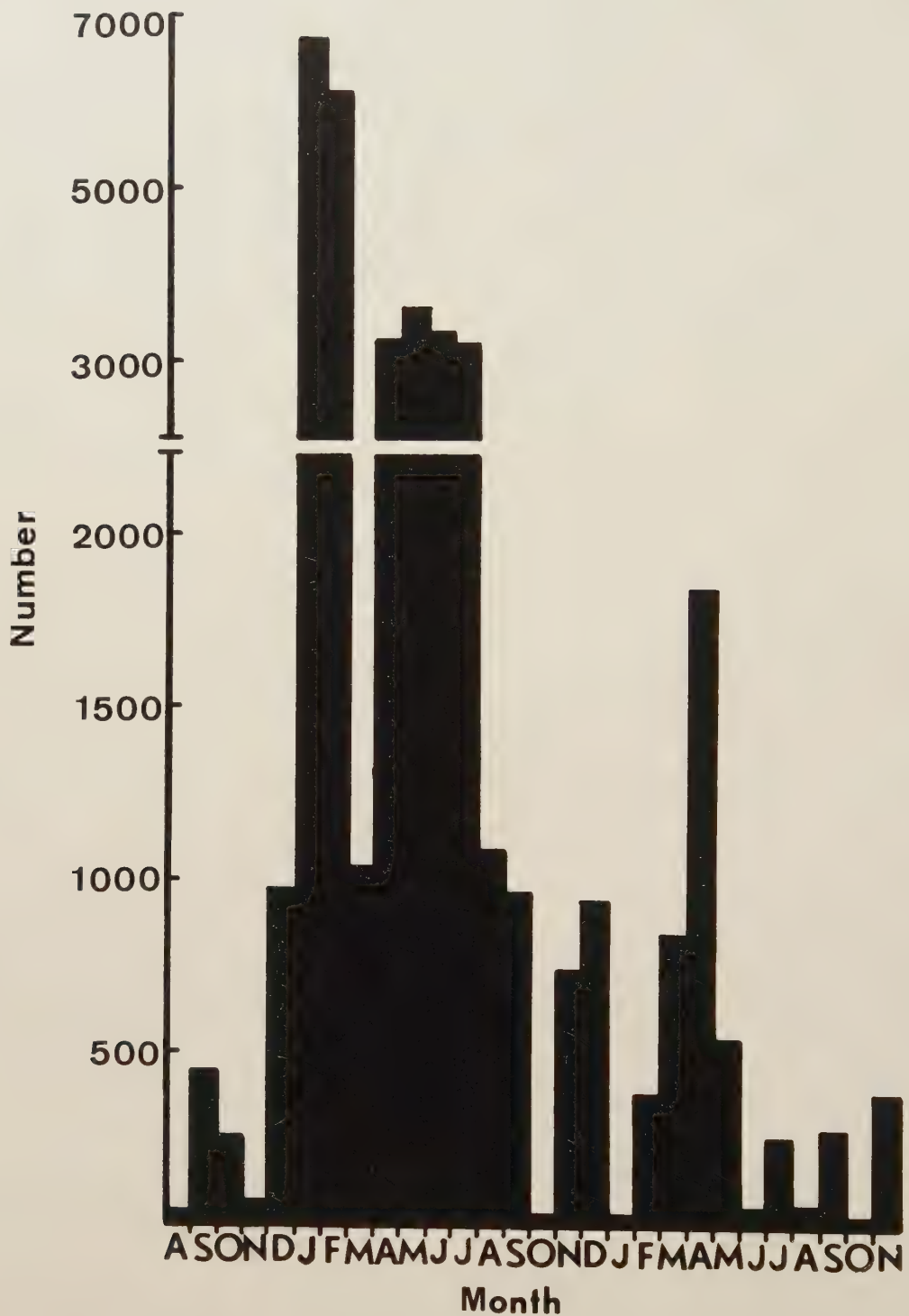


Figure 31. Seasonal abundance of *M. quinquiesperforata*, all stations combined, August 1965-November 1967. Scale change at 2250.

of movement decreased until all movement ceased (Weihe and Gray, 1968). In an attempt to examine long-term movements, Weihe and Gray tagged 96 specimens and released them for one week. Fifty specimens were recovered and the average distance traveled was 2.3 m, with the greatest distance being 4.0 m.

TABLE 18. MERISTIC DATA FOR VARIOUS CHARACTERS THAT DO NOT CHANGE WITH SIZE IN *M. QUINQUIESPERFORATA* AND *L. SEXIESPERFORATA**.

Character	Species	Mean	Range	Standard Deviation
ABAM	<i>M. quinquiesperforata</i>	5.3	5-6	0.45
	<i>L. sexiesperforata</i>	6.1	5-7	0.51
ORAM	<i>M. quinquiesperforata</i>	7.0	7-7	0.00
	<i>L. sexiesperforata</i>	6.1	6-7	0.29
ORIA	<i>M. quinquiesperforata</i>	3.0	3-3	0.00
	<i>L. sexiesperforata</i>	3.0	3-3	0.00

*N = 48 for *M. quinquiesperforata*, 23 for *L. sexiesperforata*.

TABLE 19. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS AS A FUNCTION OF TL IN *M. QUINQUIESPERFORATA* AND *L. SEXIESPERFORATA**.

Character	Species	Regression Equation	$s_{y.x}$	r
TW	<i>M. quinquiesperforata</i>	$y = 1.02x + 0.21$	2.07	1.00
	<i>L. sexiesperforata</i>	$y = 1.07x - 2.72$	2.46	1.00
TH	<i>M. quinquiesperforata</i>	$y = 0.089x + 1.19$	0.64	0.97
	<i>L. sexiesperforata</i>	$y = 0.088x + 0.31$	0.77	0.93
PL	<i>M. quinquiesperforata</i>	$y = 0.25x + 0.54$	1.01	0.99
	<i>L. sexiesperforata</i>	$y = 0.21x - 1.54$	1.17	0.97
OPW	<i>M. quinquiesperforata</i>	$y = 0.12x - 0.22$	0.71	0.98
	<i>L. sexiesperforata</i>	$y = 0.093x - 0.64$	0.64	0.96
MIPW	<i>M. quinquiesperforata</i>	$y = 0.043x - 0.10$	0.32	0.97
	<i>L. sexiesperforata</i>	$y = 0.041x - 0.19$	0.33	0.94
PAMB	<i>M. quinquiesperforata</i>	$y = 0.56x + 15.45$	4.05	0.97
	<i>L. sexiesperforata</i>	$y = 0.51x + 11.19$	3.37	0.96
ABIA	<i>M. quinquiesperforata</i>	$y = 0.038x + 7.45$	0.63	0.87
	<i>L. sexiesperforata</i>	$y = 0.042x + 7.82$	0.68	0.82
LUNAP	<i>M. quinquiesperforata</i>	$y = 0.16x + 0.40$	1.16	0.97
	<i>L. sexiesperforata</i>	$y = 0.18x + 0.04$	0.80	0.98
LUN	<i>M. quinquiesperforata</i>	$y = 0.19x + 0.09$	1.49	0.97
	<i>L. sexiesperforata</i>	$y = 0.18x - 1.70$	1.38	0.95
PS	<i>M. quinquiesperforata</i>	$y = 0.027x + 1.26$	0.25	0.95
	<i>L. sexiesperforata</i>	$y = 0.025x + 0.52$	0.28	0.90

*All characters (ordinates) plotted as function of TL (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 48 for *M. quinquiesperforata*, 23 for *L. sexiesperforata*.

Gear selectivity: The trynet collected about twice as many specimens as the dredge, with 25,623 and 12,116 specimens, respectively. However, since bottom time for the trynet was twice that for the dredge, both were about equally efficient.

Morphometric and meristic relationships: Eight measurements and six counts were taken on 48 *M. quinquesperforata* ranging from 15 to 118 mm TL. Table 18 shows statistics for those characters that do not change with size. Table 19 shows linear regression data for various characters as a function of TL.

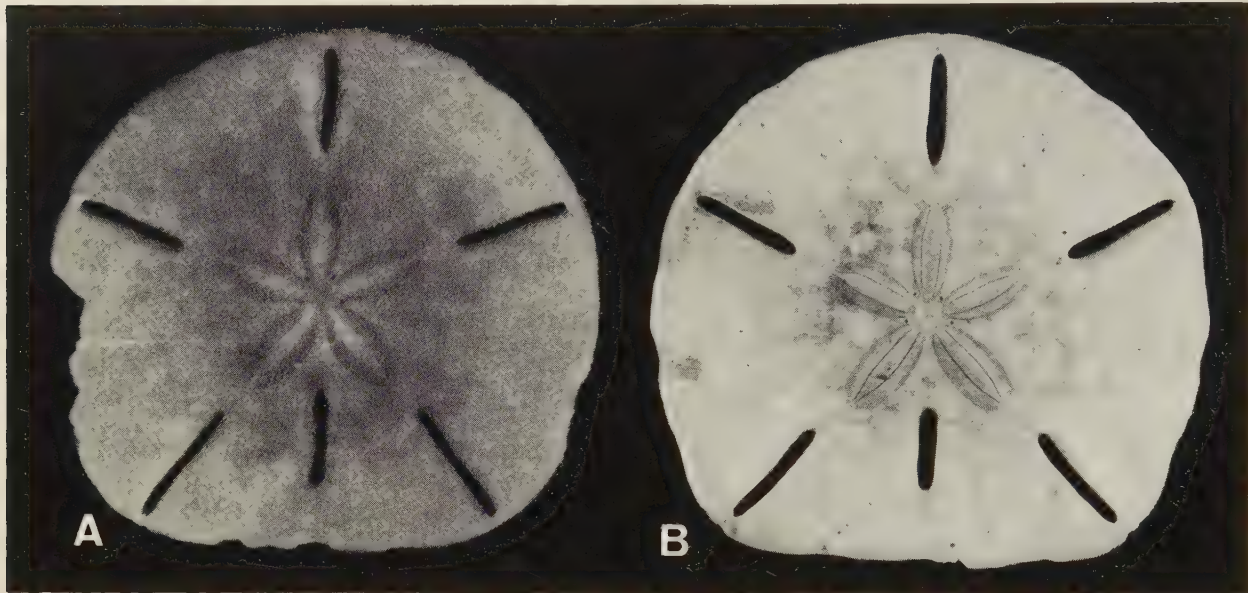


Figure 32. *Leodia sexiesperforata*, aboral aspects: A, 91 mm TL; west of Sanibel Island, 12 m; FSBC I 18977; B, cleaned test, data unknown.

Leodia sexiesperforata (Leske, 1778)

Figure 32

Echinodiscus sexies perforatus Leske, 1778, p. 199, pl. 50, figs. 3, 4.

Echinus hexaporus Gmelin, 1788, p. 3189.

Scutella sexforis Lamarck, 1816, p. 9; Desmoulins, 1837, p. 70.

Mellita hexapora: L. Agassiz, 1841, p. 41, pl. 4, figs. 4-7, pl. 4a, figs. 11, 12; L. Agassiz and Desor, 1846, p. 138; Lütken, 1864, p. 109, pl. 2, fig. 3.

Mellita similis L. Agassiz, 1841, p. 43, pl. 4, figs. 1-3.

Leodia richardsonii Gray, 1851, p. 36.

Mellita erythraea Gray, 1851, p. 36.

Mellita sexforis: A. Agassiz, 1872, pp. 141, 320, pl. 11, figs. 1-12, pl. 11d, fig. 3; Rathbun, 1886, p. 285; H. L. Clark, 1899, p. 132; 1901b, p. 264.

Mellita sexiesperforata: Jackson, 1912, p. 18; H. L. Clark, 1914, p. 77, pl. 125, figs. 22, 23; Crozier, 1919, p. 93; 1920, p. 435; H. L. Clark, 1921, p. 119; Mortensen, 1921, p. 104, pl. 4, fig. 2, pl. 13, figs. 5, 6; H. L. Clark, 1933, p. 88; Tortonese, 1933, p. 155; Bernasconi, 1941, p. 106; 1947, p. 104; Mortensen, 1948b, p. 422, pl. 58, fig. 4, pl. 61, fig. 7, pl. 72, fig. 19; A. H. Clark, 1954, p. 375; Goodbody, 1960, p. 80; Lewis, 1961, p. 53; Tommasi, 1966a, p. 241; 1966b, p. 25, figs. 45-48, pl. 6b; Roa, 1967, p. 305.

Leodia sexiesperforata: H. L. Clark, 1942, p. 282; Mayr, 1954, p. 5; Kier and Grant, 1965, p. 31, pl. 7, figs. 6-8; Kier, 1966, p. 8; Godcharles and Jaap, 1973, p. 53.

Material examined: OTHER MATERIAL: 2, 42.5, 50.6 mm; Bahamas; 1 m; USNM 32651. — 1, 79.2 mm; British Honduras; dredge; USNM 18932. — 3, 21.5- 41.0 mm; 28 September 1959; Virgin Islands, 18°47'N, 64°40'W; trawl; USNM E11949. — 1, 64.8 mm; 4 March 1953; Isle of Pines, Cuba; USNM E10348. — 2, 78.5, 80.5 mm; 1918; Barbados; USNM E4530. — 2, 39.3, 39.5 mm; 1918; Barbados; 11 m; USNM E4489. — 1, 72.4 mm; Rio de Janeiro; USNM 5388. — 3, 42.0-71.6 mm; 1899; Puerto Rico; 26m; USNM 19656-7. — 8, 45.5-81.4 mm; 19 August 1973; Bermuda; 0.5-1 m; USNM (no number).

Diagnosis: One interambulacral and five ambulacral lunules present; anterior margin of posterior interambulacral lunule extending to an imaginary line between tips of petals I and V; four genital pores.

Distribution: *Leodia sexiesperforata* occurs from Cape Hatteras, North Carolina and Bermuda, southward around the tip of Florida into the southeastern Gulf as far north as Sanibel Island. It continues from the east coast of the Yucatan Peninsula, southward along the coasts of Central and South America and throughout the Greater and Lesser Antilles, to Montevideo, Uruguay. It occurs in depths from 0 to 60 m, but is most common in depths less than 25 m.

Bottom type: The species occurs most commonly on open sand bottoms (Crozier, 1920; Kier and Grant, 1965; Kier, 1966). Godcharles and Jaap (1973) collected *L. sexiesperforata* on sand, hard sand, sand-mud, rock-sand and rock bottoms off Florida. However, the rock bottoms where this species was found probably included patches of sand, since sand dollars do not live on rock bottoms.

Diet: *Leodia sexiesperforata* is a ciliary-mucus feeder, collecting particles on its aboral surface and transporting them through the lunules or around the ambitus to food grooves on the oral surface that lead to the mouth (Goodbody, 1960). Sizes of particles selectively retained vary from 1 to 20 μ m in diameter. Within this size range, there appears to be no further sorting; particles include algal cells, detritus and sand grains (Goodbody, 1960).

Growth and reproduction: Crozier (1920) reported that *L. sexiesperforata* in Bermuda attains a test width of about 22 mm after six months' growth, 57 mm TW after 18 months, 72 mm TW after 30 months, 97 mm TW after 42 months, and 110 mm TW after 54 months. However, these determinations were made on relatively few specimens, and sizes should be verified. Crozier used TW to indicate size since specimens were often broken along the posterior margin of the test. TL was used in this study to indicate size for the irregular echinoids; Table 19 shows the relationship between TL and TW for *L. sexiesperforata*.

Very little information is published about reproduction in this species. Mortensen (1921) obtained a few ripe gametes on 8 April 1916 at Tobago. Metamorphosis occurred 5 to 7 days after fertilization.

Morphometric and meristic relationships: Eight measurements and six counts were taken on 23 *L. sexiesperforata* ranging from 22 to 98 mm TL. Table 18 shows statistics for those characters that do not change with size. Table 19 shows linear regression data for various characters as a function of TL.

Remarks: Although no specimens of this species were collected during Project Hourglass, Godcharles and Jaap (1973) reported it from a depth of 12.2 m 10 miles due west of Sanibel Island, in the area between Hourglass Stations I and J; an illustrated specimen (Figure 32A) is from that collection. They also found the species at five stations in depths of 10.7 to 13.7 m off Cape Romano.

Encope aberrans Martens, 1867

Figure 33

Encope aberrans Martens, 1867, p. 112; Phelan, 1972, p. 125, text-figs. 2c, 8-10; Godcharles and Jaap, 1973, p. 52.

Material examined: HOURGLASS STATION B: 2, 119, 124 mm; 18 October 1966; dredge. — 3, 60-140 mm; 19 November 1966; dredge. — fragments; 13 December 1966; dredge. — 1, 110 mm; 20 January 1967; dredge. — 2, 119, 122 mm; 5 February 1967; dredge; FSBC I 10998. — 5, 113-129 mm; 3 April 1967; dredge; FSBC I 10999. — 1, 44 mm; 5 October 1967; dredge. — 1, 135 mm; 20 November 1967; trawl; FSBC I 11001. — 1, 123 mm; 20 November 1967; dredge. — HOURGLASS STATION C: 1, 20 mm; 19 November 1966; trawl; FSBC I 6792. — HOURGLASS STATION J: 4, 94-107 mm; 6 August 1965; trawl; FSBC I 1487. — 8, 99-116 mm; 6 August 1965; dredge; FSBC I 780. — 1, 127 mm; 6 June 1967; dredge. — 2 dead tests, 100, 105 mm; 6 August 1967; SCUBA. — 2, 38, 47 mm; 14 November 1967; trawl; FSBC I 11000. — HOURGLASS STATION K: 1, 30 mm; 12 November 1965; trawl; FSBC I 1180. — 20, 20-133 mm; 12 October 1966; trawl. — 1, 21 mm; 12 November 1966; dredge; FSBC I 10997. — 1, 26 mm; 6 December 1966; trawl. — 3, 34-50 mm; 12 January 1967; dredge. — 2, 18, 55 mm; 7 April 1967; trawl.

Distribution: *Encope aberrans* occurs from Cape Hatteras, North Carolina south to the Bahama Islands and throughout the Gulf of Mexico. It occurs in depths from 12 to 90 m.

Bottom type: The species occurs on bottoms of crushed shell and quartz sand and was most common at Stations B, J and K (Table 20). Phelan (1972) speculated that this species prefers a different particle size than *E. michelini*, based on differences in sizes of food grooves. Since *E. aberrans* has relatively larger food grooves, it is possible that it prefers a larger substrate particle size or at least utilizes larger particles when feeding.

Gear selectivity: The dredge collected 27 specimens and the trynet 34 specimens.

TABLE 20. NUMBERS OF *ENCOPE ABERRANS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Encope aberrans																																	
STA	1965					1966												1967															TOT
	A	S	O	N	D	J	F	M	A	M	J	J	Jsp	A	S	O	N	D	J	Jsp	F	M	A	M	J	J	A	S	O	N			
A																																	
B ₁																					2		5						1		8		
B ₂																2	3		1										2		8		
C ₁																																	
C ₂																	1														1		
D ₁																																	
D ₂																																	
E																																	
I																																	
J	12																									1			2		15		
K				1													20	1	1	3			2										
L																																	
M																																	
TOT	12			1													22	5	1	4		2	7		1				1	4	60		

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

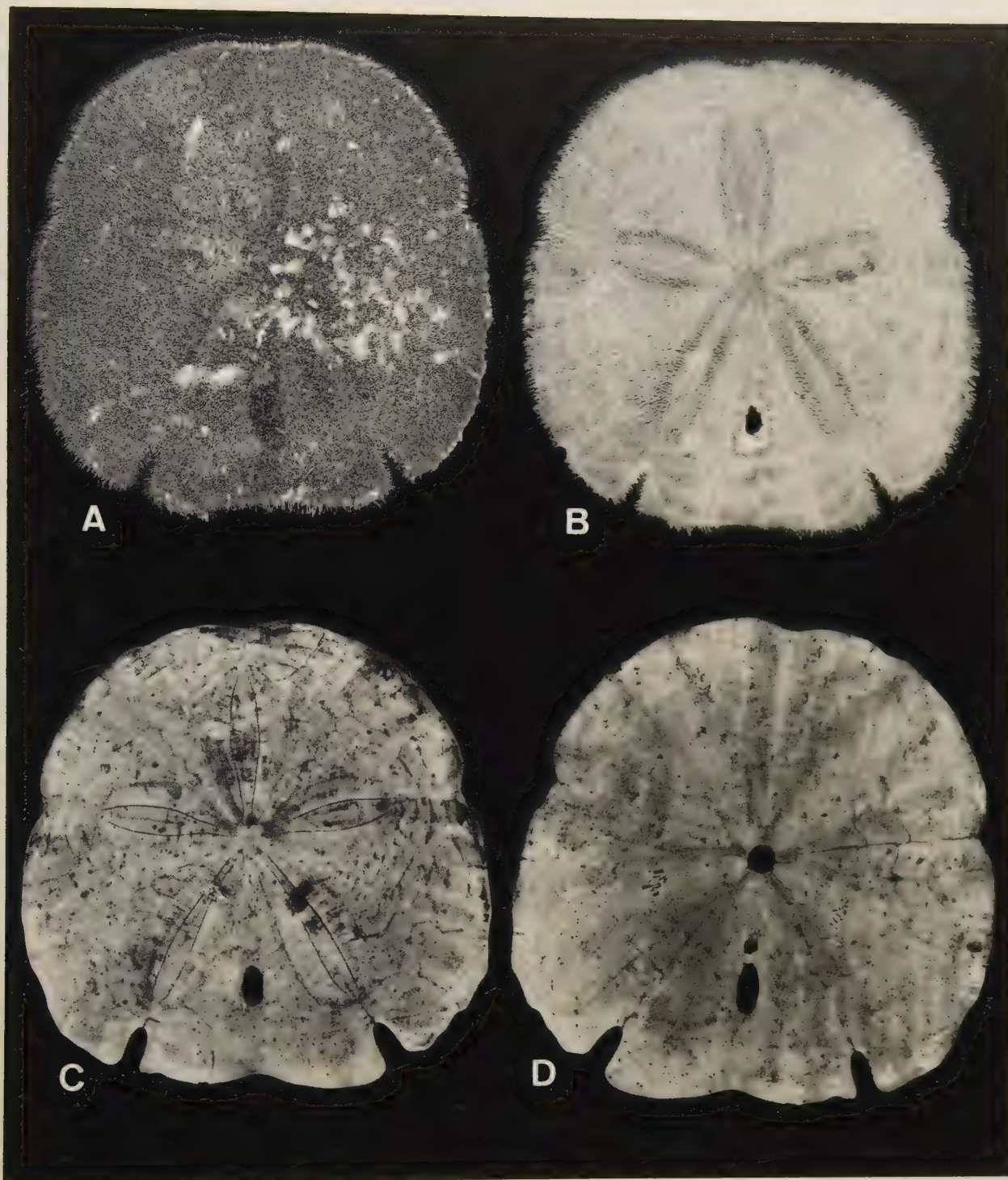


Figure 33. *Encope aberrans*: A, aboral aspect, 87 mm TL; off Englewood, Florida west coast, 20 m; FSBC I 18975; B, aboral aspect, pigment removed; 88 mm TL; same data; C, aboral aspect, cleaned test, 102 mm TL; Station J, August 1965; FSBC I 780; D, oral aspect, same specimen.

Morphometric and meristic relationships: Ten measurements and six counts were taken on 19 *E. aberrans* ranging from 18 to 137 mm TL. Table 21 shows meristic data for characters that do not change with size.

TABLE 21. MERISTIC DATA FOR VARIOUS CHARACTERS THAT DO NOT CHANGE WITH SIZE IN *E. ABERRANS* AND *E. MICHELINI*.

Character	Species	Mean	Range	Standard Deviation
ABAM	<i>E. aberrans</i>	5.4	5-6	0.11
	<i>E. michelini</i>	6.2	5-7	0.12
ORAM	<i>E. aberrans</i>	6.0	6-6	0.00
	<i>E. michelini</i>	6.7	6-7	0.11
ORIA	<i>E. aberrans</i>	3.0	3-3	0.00
	<i>E. michelini</i>	3.0	3-3	0.00
OPAMB	<i>E. aberrans</i>	11.4	11-12	0.11
	<i>E. michelini</i>	12.9	12-14	0.19

Table 22 shows linear regression data for various characters as a function of TL. *Encope aberrans* further differs from *E. michelini* by possessing a shorter posterior interambulacral lunule, a larger peristome, and a shallower marginal notch at the ambulacra (Figure 34).

TABLE 22. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS AS A FUNCTION OF TL IN *E. ABERRANS* AND *E. MICHELINI**.

Character	Species	Regression Equation	$s_{y.x}$	r
TW	<i>E. aberrans</i>	$y = 0.95x + 1.55$	3.42	1.00
	<i>E. michelini</i>	$y = 0.93x + 3.22$	2.24	1.00
TH	<i>E. aberrans</i>	$y = 0.14x - 0.99$	1.91	0.96
	<i>E. michelini</i>	$y = 0.12x - 1.78$	1.33	0.94
PL	<i>E. aberrans</i>	$y = 0.35x - 3.22$	1.52	1.00
	<i>E. michelini</i>	$y = 0.29x - 2.33$	1.06	0.99
OPW	<i>E. aberrans</i>	$y = 0.15x - 1.36$	1.23	0.98
	<i>E. michelini</i>	$y = 0.13x - 1.40$	0.81	0.98
MIPW	<i>E. aberrans</i>	$y = 0.045x - 0.03$	0.71	0.95
	<i>E. michelini</i>	$y = 0.041x + 0.18$	0.51	0.92
PAMB	<i>E. aberrans</i>	$y = 0.79x + 8.73$	4.55	0.99
	<i>E. michelini</i>	$y = 0.53x + 22.7$	4.99	0.95
ABIA	<i>E. aberrans</i>	$y = 0.035x + 8.12$	0.74	0.91
	<i>E. michelini</i>	$y = 0.030x + 8.92$	0.48	0.88
LUNAP	<i>E. aberrans</i>	$y = 0.28x - 1.11$	1.67	0.99
	<i>E. michelini</i>	$y = 0.21x + 0.48$	1.06	0.99

*All characters (ordinates) plotted as function of TL (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 19 for both species.

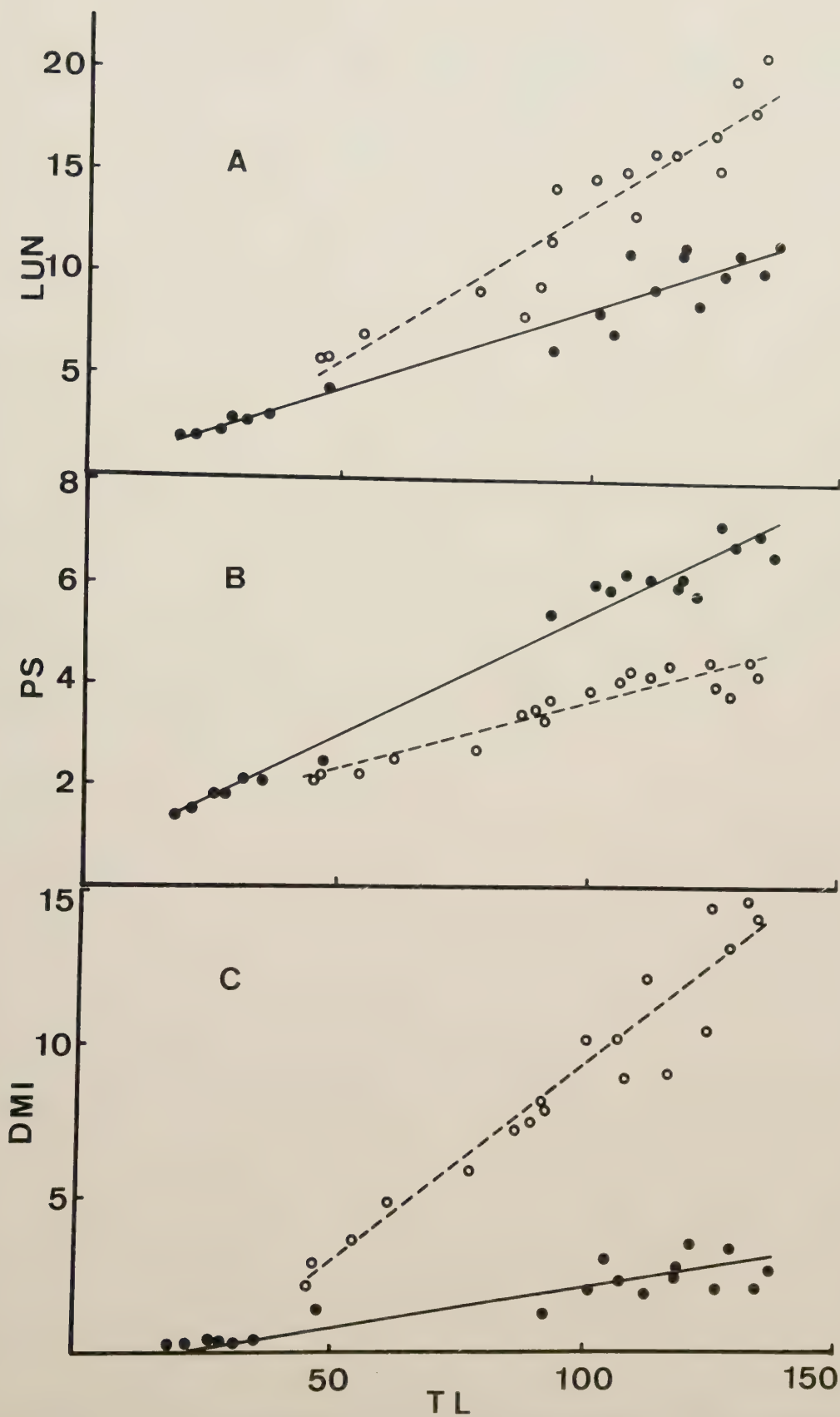


Figure 34. A, length of posterior interambulacral lunule (LUN); B, peristome diameter (PS); C, depth of marginal notch (DMI) in ambulacrum II as functions of TL in *E. aberrans* (closed circles) and *E. michelini* (open circles).

Encope michelini L. Agassiz, 1841

Figure 35

Encope michelini L. Agassiz, 1841, p. 58, pl. 6a, figs. 9, 10; A. Agassiz, 1869, p. 266; 1872, pp. 127, 329, pl. 12b, fig. 4, pl. 12c, figs. 3, 4, pl. 12d, fig. 1; 1883, p. 44; Rathbun, 1885, p. 615; 1886, p. 286; H. L. Clark, 1914, p. 75; Mortensen, 1948b, p. 441, pl. 70, fig. 23; A. H. Clark, 1954, p. 375; Mayr, 1954, p. 10; Hildebrand, 1955, p. 196; Caso, 1961, p. 281, text-fig. 113; Dragovich and Kelly, 1964, p. 93; Kier and Grant, 1965, p. 33, pl. 5, fig. 7, pl. 7, figs. 1-8, pl. 15, fig. 7; Stokes et al., 1968, p. 15; Lyons et al., 1971, p. 38; Menzel, 1971, p. 86; Jolley, 1972, p. 37; Phelan, 1972, p. 124, text-figs. 1, 2b, 5-7; Godcharles and Jaap, 1973, p. 52.

Material examined: HOURGLASS STATION B: 3, 101-110 mm; 3 August 1965; dredge. — 1, 54 mm; 4 October 1965; trawl; FSBC I 11002. — 16, 61-112 mm; 8 October 1966; dredge. — 46, 77-114 mm; 6 November 1966; dredge. — 5, 107-110 mm; 19 November 1966; dredge; FSBC I 11003. — 1, 92 mm; 1 December 1966; trawl. — 28, 65-125 mm; 1 December 1966; dredge. — 3, 111-125 mm; 13 December 1966; dredge. — 37, 94-131 mm; 6 January 1967; dredge. — 10, 82-118 mm; 20 January 1967; dredge. — 1, 106 mm; 25 January 1967; trawl. — 1, 80 mm; 2 March 1967; dredge. — 14, 100-132 mm; 14 March 1967; dredge. — 28, 62-124 mm; 3 April 1967; dredge; FSBC I 11005. — 9, 106-113 mm; 11 April 1967; dredge; FSBC I 11006. — 40, 94-127 mm; 2 June 1967; dredge; FSBC I 11109. — 27, 86-114 mm; 1 July 1967; dredge. — 20, 97-112 mm; 11 July 1967; dredge; FSBC I 11007. — 5, 117-123 mm; 1 August 1967; dredge. — 7, 95-125 mm; 11 August 1967; dredge; FSBC I 11009. — 2, 113, 117 mm; 5 October 1967; dredge. — 17, 107-124 mm; 2 November 1967; dredge. — 2, 121, 123 mm; 20 November 1967; dredge. — 1, 133 mm; 20 November 1967; trawl. — HOURGLASS STATION I: 4, 85-116 mm; 13 January 1967; trawl; FSBC I 1627. — 2, both 45 mm; 7 August 1967; trawl. — HOURGLASS STATION J: 1 dead test, 111 mm; 6 August 1967; SCUBA. — HOURGLASS STATION M: dead test fragment; 7 December 1966; dredge; FSBC I 11004. — dead test fragment; 15 November 1967; dredge; FSBC I 11010.

Diagnosis: One interambulacral lunule present in interambulacrum 5; five marginal notches present, one in each ambulacrum; food grooves shallow, narrow, turning gentle curves toward peristome; peristome small; 12-14 ambulacral plates between peristome and tip of petal II or IV.

Distribution: *Encope michelini* has nearly the same distribution as *E. aberrans*. It occurs from Cape Hatteras, North Carolina southward around the southern tip of Florida, throughout the Gulf to Cozumel, Mexico, but is not yet known from the Bahamas. It occurs in depths from 3 to 90 m.

TABLE 23. NUMBERS OF *ENCOPE MICHELINI* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Encope <i>micelini</i>																																		TOT
STA	1965					1966															1967													TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N				
A																																		
B ₁	3		2	9		3	4	1	7	4	3	5		1			46	29	37	1		1	28			27	5		2	17	235			
B ₂			2			1		1	3	6	50	18		7	5	16	5	3	10			14	9		40	20	7		3		220			
C ₁																																		
C ₂																																		
D ₁																																		
D ₂																																		
E																																		
I						4		5																			2				11			
J						4				16		87																			107			
K	5						2							24	2	1															34			
L																																		
M																																		
TOT	8		4	9		12	6	7	10	26	53	110		32	7	17	51	32	47	1		15	37		40	47	14		2	20	607			

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

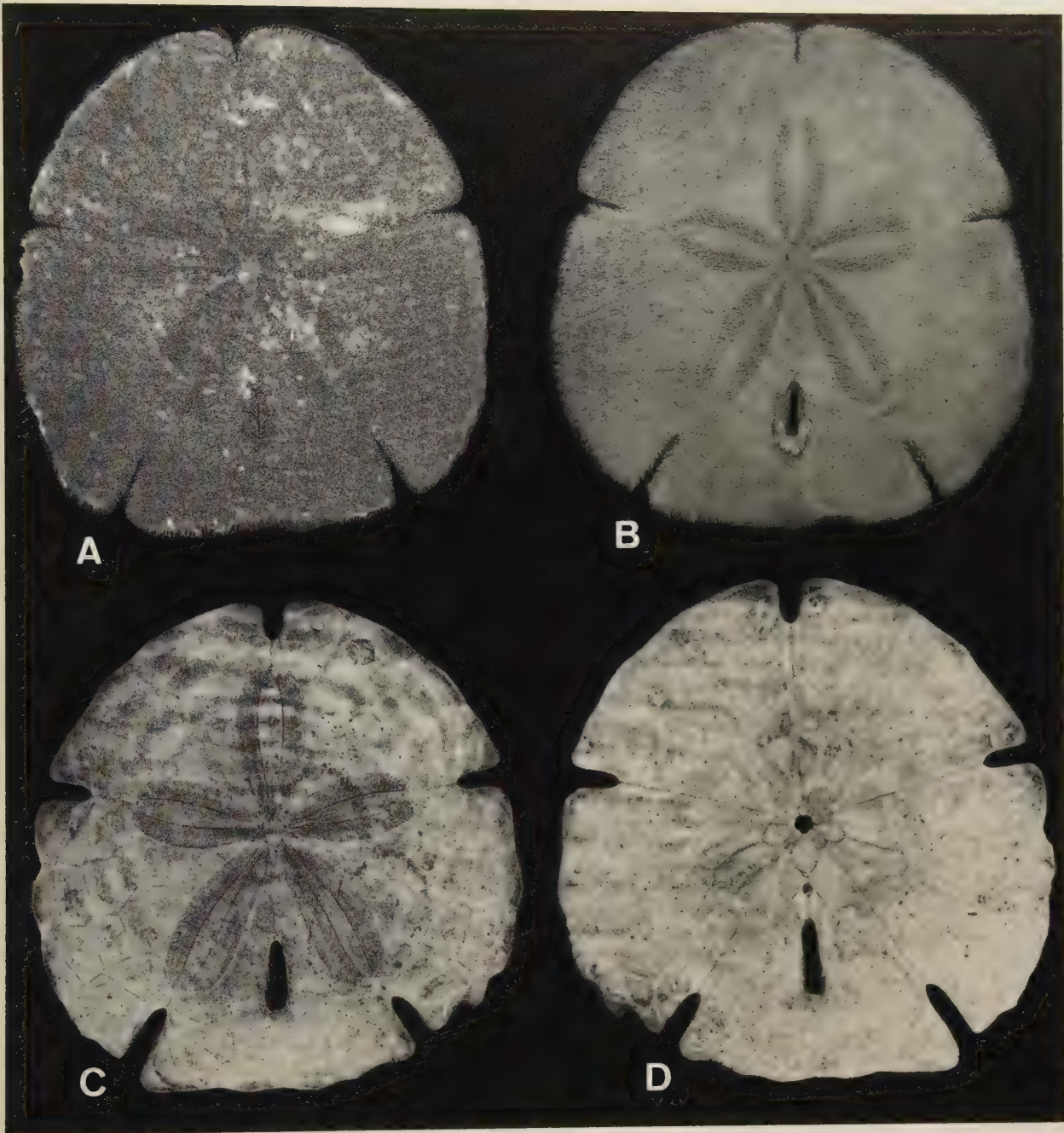


Figure 35: *Encope michelini*: A, aboral aspect, 91 mm TL; off Englewood, Florida west coast, 20 m; FSBC I 18976; B, aboral aspect, pigment removed, 87 mm TL; same data; C, aboral aspect, cleaned test; 101 mm TL; Station B, July 1967; USNME15295; D, oral aspect, same specimen.

Bottom type: According to Kier and Grant (1965), *E. michelini* occurs in areas of deep sand with little or no turtle grass or filamentous algae. Hourglass specimens occurred on bottoms composed of crushed shell and quartz sand, primarily at Station B (Table 23).

Gear selectivity: The dredge collected 320 specimens, and the trynet collected 10 specimens.

Morphometric and meristic relationships: Ten measurements and six counts were taken on 19 *E. michelini* ranging from 45 to 134 mm TL. Table 21 shows meristic data for those characters that do not change with size. Table 22 shows linear regression data for various characters as a function of TL. Figure 34 shows differences between *E. michelini* and *E. aberrans* in length of the posterior interambulacral lunule, peristome diameter, and depth of the marginal notch at ambulacrum II or IV.

Encope spp.

Material examined: HOURGLASS STATION B: 1, 129 mm; 4 October 1965; dredge. — 2, 106, 112 mm; 20 October 1965; dredge. — 3, 64-66 mm; 8 November 1965; trawl. — 6, 85-126 mm; 8 November 1965; dredge. — 2, 104, 108 mm; 3 January 1966; trawl. — 1, 118 mm; 3 January 1966; dredge. — 1, 120 mm; 19 January 1966; dredge. — 4, 100-130 mm; 7 February 1966; dredge. — 1 adult; 3 March 1966; dredge. — 1, 122 mm; 26 March 1966; dredge. — 7, 104-119 mm; 6 April 1966; dredge. — 1, 110 mm; 15 April 1966; trawl. — 2, 99, 107 mm; 15 April 1966; dredge. — 4, 97-122 mm; 2 May 1966; dredge. — 6, 104-135 mm; 18 May 1966; dredge. — 2, 20, 105 mm; 6 June 1966; trawl. — 1, 133 mm; 6 June 1966; dredge. — 50, 63-109 mm; 17 June 1966; dredge. — 1, 19 mm; 2 July 1966; trawl. — 4, 103-129 mm; 2 July 1966; dredge. — 18, 33-106 mm; 10 July 1966; dredge. — 1, 105 mm; 1 August 1966; dredge. — 7, 100-117 mm; 10 August 1966; dredge. — 2, 21, 34 mm; 8 September 1966; trawl. — 3, 103-114 mm; 8 September 1966; dredge. — HOURGLASS STATION I: 1, 98 mm; 21 March 1966; trawl. — 4, 92-104 mm; 21 March 1966; dredge. — HOURGLASS STATION J: 4, 110-116 mm; 13 January 1966; dredge. — 1, 97 mm; 11 May 1966; trawl. — 15, 95-122 mm; 11 May 1966; dredge. — 87, 104-150 mm; 5 July 1966; dredge. — HOURGLASS STATION K: 5 adults; 6 August 1965; trawl. — 2, 112, 123 mm; 14 February 1966; dredge. — 24, 100-125 mm; 5 August 1966; dredge. — 1, 22 mm; 4 September 1966; trawl. — 1, 48 mm; 4 September 1966; dredge. — 1, 20 mm; 12 October 1966; dredge.

Remarks: According to Mortensen (1948b), the two species of *Encope* reported from the Gulf of Mexico were *E. michelini* L. Agassiz, 1841 and *E. emarginata* (Leske, 1778). Specimens collected in this study were all originally identified as *E. michelini*, and in the early part of the study some were measured and discarded. Phelan (1972) revealed that *E. emarginata* does not occur in the Gulf, but rather is a Central and South American species. Specimens previously thought to be all *E. michelini* are instead two species, *E. michelini* and *E. aberrans* Martens, 1867. Reexamination of Hourglass *Encope* indicates both species were collected, sometimes in the same sample. Therefore, all above discarded specimens must be referred to *Encope* spp. However, those from Station I were probably *E. michelini*, and those from Station K were probably *E. aberrans*, since only these species were identified from these respective stations; such occurrence of *E. aberrans* would be consistent with other bathymetric and distributional information.

ORDER CASSIDULOIDA CLAUS, 1880

Two species belonging to this order have been collected in the Gulf of Mexico, and another two species have been recorded from nearby waters (Table 2).

KEY TO CASSIDULOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Test high, height greater than 60 percent TL; aboral aspect of test circular *Conolampas sigsbei* (A. Agassiz)
1. Test low, height less than 60 percent TL; aboral aspect of test oval 2

- 2. Three genital pores; ambulacra rudimentary, not forming petals *Neolampas rostellata* A. Agassiz
- 2. Four genital pores; pore series curved, forming petals 3
- 3. Periproct inframarginal; one pore series of a petal about 50 percent as long as other pore series in petal*Echinolampas depressa* Gray
- 3. Periproct supramarginal; pore series of petals about equal in length .*Cassidulus caribaeorum* Lamarck

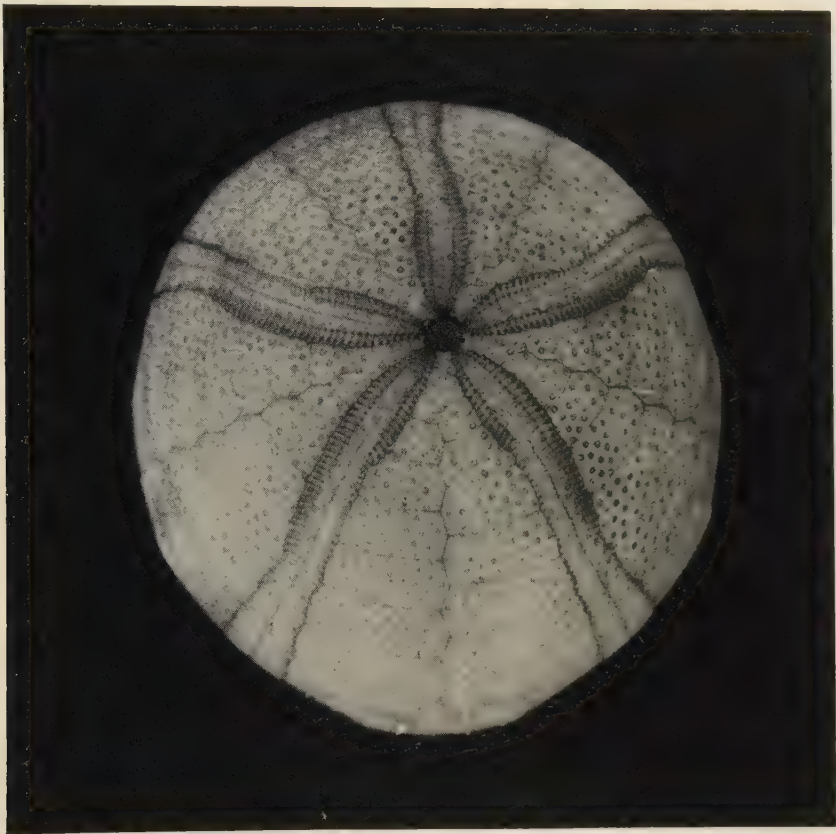


Figure 36. *Echinolampas depressa*, aboral aspect, 35 mm TL; Gulf of Mexico, 25°00'N, 84°00'W, 132 m; USNM E15565.

Family Echinolampadidae Gray, 1851

Echinolampas depressa Gray, 1851

Figure 36

Echinolampas depressus Gray, 1851, p. 38.

Echinolampas caratomoides A. Agassiz, 1869, p. 269.

Echinolampas depressa: A. Agassiz, 1872, pp. 114, 335, 551, pl. 16, figs. 6, 7, 17-22; 1883, p. 46, pl. 16, pl. 24, figs. 1-5; 1904, p. 118, text-fig. 155, pl. 64, figs. 2-5, pl. 65, figs. 1-4; H. L. Clark, 1917, p. 115, pl. 144, figs. 18, 19, pl. 153, fig. 8; Mortensen, 1948a, p. 287, pl. 11, fig. 4, pl. 13, fig. 7, pl. 14, fig. 3; A. H. Clark, 1954, p. 375.

Material examined: HOURGLASS STATION D: 1, 25.1 mm; 7 June 1966; dredge. — fragments; 2 December 1966; trawl; FSBC I 6794. — 1, 3.7 mm; 12 May 1967; dredge; FSBC I 11103. — 1, 3.5 mm; 21 June 1967; dredge. — 1 dead test, 2.5 mm; 2 July 1967; dredge. — 1, 2.9 mm; 6 October 1967; trawl. — HOURGLASS STATION E: fragments; 31 August 1965; trawl; FSBC I 6814. — 3 dead tests, 33.0-43.2 mm; 7 June 1966; trawl. — 2, 31.0, 34.9 mm, 8 dead tests, 30.3-44.0 mm; 7 June 1966; dredge; FSBC I 11101. — 3 dead tests, 3.1-33.2 mm; 2 August 1966; dredge. — 5 dead tests, 29.8-43.7 mm; 3 March 1967; dredge. — 1 dead test, 43.8 mm; 4 April 1967; dredge. — fragments; 4 April 1967; trawl. — 1 dead test, 2.5 mm; 2 August 1967; dredge. — fragments; 3 November 1967; dredge. — HOURGLASS STATION K: 1 dead test, 2.1 mm; 14 November 1967; dredge; FSBC I 11104. — HOURGLASS STATION L: adult fragment; 4 September 1965; dredge. — 1, 7.3 mm; 12 April 1966; dredge. — 1, 4.2 mm; 6 August 1966; trawl; FSBC I 4464. — 1, 6.3 mm; 6 August 1966; dredge; FSBC I 4459. — 1 adult; 5 September 1966; trawl; FSBC I 4015. — 11, 2.0-24.1 mm, 4 dead tests, 2.5-3.7 mm; 5 September 1966; dredge; FSBC I 4107. — 1, 15.3 mm; 13 October 1966; trawl; FSBC I 4741. — 3, 2.2-7.5 mm; 13 October 1966; dredge. — 2, 3.3, 3.5 mm; 13 November 1966; dredge. — dead test fragment; 13 January 1967; trawl. — 2, 5.6, 13.4 mm, 1 dead test, 24.0 mm; 16 February 1967; dredge. — fragments; 9 March 1967; dredge. — 1 dead test, 2.9 mm; 8 April 1967; dredge. — 1 dead test, 3.3 mm; 15 November 1967; trawl. — 1, 2.1 mm, 1 dead test, 2.9 mm; 15 November 1967; dredge. — HOURGLASS STATION M: 1 dead test, 37.3 mm; 14 December 1965; dredge. — 1 dead test, 27.1 mm; 12 April 1966; trawl; FSBC I 3562. — 1, 8.5 mm; 6 August 1966; dredge; FSBC I 3773. — 9, 2.0-5.8 mm, 42 dead tests, 2.1-4.6 mm; 5 September 1966; dredge; FSBC I 4544. — 2, 18.7, 22.0 mm, 2 dead tests, 2.1, 3.7 mm; 13 November 1966; dredge; FSBC I 11102. — 2, 4.6, 5.6 mm; 31 January 1967; trawl. — fragment; 16 February 1967; dredge. — fragment; 6 July 1967; trawl. — 3 dead tests, 3.1-4.2 mm; 6 July 1967; dredge.

Diagnosis: Test low, height less than 60 percent TL; aboral aspect of test oval; phyllodes and bourrelets present; mouth central, wider than long, without labrum; lantern present in very small juveniles (less than about 5 mm TL), resorbed in larger juveniles and adults; four genital pores; pore series curved, forming petals with series of unequal length.

Distribution: *Echinolampas depressa* occurs from Cape Canaveral, Florida southward through the Greater and Lesser Antilles and along the South American coast from off Caracas, Venezuela to off Surinam. It is known in the Gulf of Mexico from St. Petersburg, Florida southward to Cuba and from the Campeche

TABLE 24. NUMBERS OF *ECHINOLAMPAS DEPRESSA* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Echinolampas depressa																																	
STA	1965					1966															1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N			
A																																	
B ₁																																	
B ₂																																	
C ₁																																	
C ₂																																	
D ₁											1													1					1		3		
D ₂																									1						1		
E											2																				2		
I																																	
J																																	
K																																	
L								1						2	12	4	2				2								1		24		
M														1	9		2			2											14		
TOT								1		3				3	21	4	4			2	2			1	1				1	1	44		

Subscripts 1, 2 and sp designate regular, post and supplementary cruises.

Banks to Cozumel. It occurs in depths from 37 to 310 m. Specimens from Stations D and E represent northern range extensions in the Gulf of Mexico.

Bottom type: Hourglass specimens were collected on bottoms composed primarily of algal sand (*Lithothamnion* spp.) at Stations D, E, L and M (Table 24).

Diet: According to Mortensen (1948a), the gut contains foraminiferans.

Gear selectivity: Forty-one specimens and 74 dead tests were collected in the dredge; only ten specimens and six dead tests were collected in the trynet.

Morphometric and meristic relationships: Six measurements and three counts were taken on 26 *E. depressa* ranging from 5 to 42 mm TL. Table 25 shows linear regression data for various characters as a function of TL. The only character examined that does not increase with size is OPAMB. The mean is 47.5 ± 2.84 , and the range is 43 to 52 plates.

TABLE 25. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS
AS A FUNCTION OF TL IN *E. DEPRESSA**.

Character	Regression Equation	$s_{y.x}$	r
TW	$y = 0.85x + 0.36$	0.77	1.00
TH	$y = 0.54x + 1.17$	1.37	0.98
AS	$y = 0.044x + 0.43$	0.12	0.97
PW	$y = 0.13x + 1.35$	0.27	0.98
PSW	$y = 0.11x + 1.20$	0.28	0.98
IA	$y = 0.14x + 12.48$	1.23	0.82
PAMB	$y = 0.83x + 7.47$	2.97	0.96

*All characters (ordinates) plotted as function of TL (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 26.

Predators: One specimen of *E. depressa* was found in the stomach of a sea star, *Luidia alternata* (Say, 1825). Nineteen of the 21 dead tests of adults had single, small holes drilled through them, presumably by gastropods.

ORDER HOLASTEROIDA DURHAM AND MELVILLE, 1957

Only one species belonging to this order, *Pourtalesia miranda* A. Agassiz, has been collected in the Gulf of Mexico and nearby waters (Table 2). Most members of this group typically occur in depths greater than those sampled during the Hourglass Cruises.

ORDER SPATANGOIDA CLAUS, 1876

This order has the largest number of species and includes 21 which have been collected in the Gulf of Mexico and an additional seven which are recorded from nearby waters (Table 2).

KEY TO SPATANGOIDA OF THE GULF OF MEXICO AND ADJACENT WATERS

1. Paired petals poorly developed or quite rudimentary, never forming depression in test 2
1. Paired petals well developed, generally forming distinct depression in test 9
2. Anterior unpaired petal (III) well developed, deeply sunken ... *Aceste bellidifera* Wyville-Thomson
2. Petal III not well developed nor deeply sunken 3
3. Areoles of primary tubercles distinctly sunken, forming internal bulges or pouches 4
3. Areoles not deeply sunken 5
4. Peripetalous fasciole absent; no primary tubercles on interambulacrum 5; three (rarely four) genital pores; primary tubercles non-crenulate; small forms, generally less than 35 mm TL
..... *Homolampas fragilis* (A. Agassiz)
4. Peripetalous fasciole present; primary tubercles on interambulacrum 5; four genital pores; primary tubercles crenulate; generally large forms, up to 110 mm TL *Araeolampas atlantica* Serafy
5. Ambulacral petals very rudimentary; pore-pairs barely visible without magnification; ambulacral plates within petals generally hexagonal, not much wider than high; two genital pores; small forms, generally less than 35 mm TL *Paleobrissus hilgardi* A. Agassiz
5. Ambulacral petals poorly developed but clearly visible; ambulacral plates within petals generally rectangular, much wider than high; three or four genital pores; large forms, commonly reaching 130 mm TL 6
6. Marginal fasciole present; ambulacrum III forming frontal notch
..... *Linopneustes longispinus* (A. Agassiz)
6. Marginal fasciole absent; no frontal notch 7
7. Ambulacra I and V with primary tubercles on oral side *Archaeopneustes hystrix* (A. Agassiz)
7. Ambulacra I and V naked on oral side 8
8. Paired petals with bare interporiferous zone *Paleopneustes cristatus* A. Agassiz
8. Paired petals with tuberculate interporiferous zone *Paleopneustes tholoformis* Chesher
9. Subanal fasciole present (Figure 2b) 10
9. Subanal fasciole absent 19
10. Inner fasciole present (Figure 2a) *Echinocardium laevigaster* A. Agassiz
10. Inner fasciole absent 11

11.	Peripetalous fasciole double anteriorly	12
11.	Peripetalous fasciole single anteriorly	13
12.	Labrum fully tuberculate; primary tubercles numerous on aboral side, continuing outside peripetalous fasciole in interambulacra 1 and 4; frontal notch much wider than deep, depth 7.2 to 12.8 percent TL	<i>Plethotaenia spatangoides</i> (A. Agassiz)
12.	Labrum naked adjacent to plastron; primary tubercles not numerous on aboral side, not continuing outside peripetalous fasciole; frontal notch deeper than wide, depth 12.5 to 16.0 percent TL	<i>Plethotaenia angularis</i> Cheshier
13.	Large primary tubercles within peripetalous fasciole giving rise to very long primary spines	<i>Plagiobrissus grandis</i> (Gmelin)
13.	No such large primary tubercles	14
14.	Subanal fasciole cordiform or shield-shaped	<i>Rhinobrissus micrasteroides</i> A. Agassiz
14.	Subanal fasciole reniform	15
15.	Large forms, adults up to 200 mm TL; adapical portion of subanal fasciole lost in adults; ambulacra I and V narrow on oral surface, greatest width less than 40 percent greatest width of plastron	<i>Meoma ventricosa ventricosa</i> (Lamarck)
15.	Small forms, generally less than 100 mm TL; subanal fasciole complete in adults; ambulacra I and V wide on oral surface, greatest width greater than 40 percent greatest width of plastron	16
16.	Labrum extending posteriorly to second adjoining ambulacral plates	<i>Brissopsis elongata elongata</i> Mortensen
16.	Labrum extending posteriorly to first adjoining ambulacral plates	17
17.	Posterior petals divergent proximally; four ambulacral plates crossing subanal fasciole	<i>Brissopsis alta</i> Mortensen
17.	Posterior petals confluent proximally, divergent distally; four or five ambulacral plates entering subanal fasciole	18
18.	Normally four ambulacral plates entering subanal fasciole; peripetalous fasciole never crossing plate 4b in interambulacrum 3	<i>Brissopsis mediterranea</i> Mortensen
18.	Normally five ambulacral plates entering subanal fasciole; peripetalous fasciole frequently crossing plate 4b in interambulacrum 3	<i>Brissopsis atlantica</i> Mortensen
19.	Lateroanal fasciole absent or exceptionally rudimentary	20
19.	Lateroanal fasciole present, distinct (Figure 2a)	23
20.	Lateroanal fasciole always absent; four genital pores	<i>Hemiasperus expurgatus</i> Lovén
20.	Lateroanal fasciole absent or occasionally rudimentary; two genital pores	21
21.	Posterior paired petals less than 50 percent length of anterior paired petals; posterior portion of test much higher than anterior portion; apical system posterior	<i>Hypselaster brachypetalous</i> H. L. Clark
21.	Posterior paired petals more than 50 percent length of anterior paired petals; posterior portion of test not distinctly higher than anterior portion; apical system central	22

22. Test height greater than 67 percent TL; petals distinctly sunken; peripetalous fasciole sharply indented at interambulacra 1 and 4 *Hypselaster limicolus* (A. Agassiz)
22. Test height less than 67 percent TL; petals slightly sunken; peripetalous fasciole nearly circular, only slightly curving inward at interambulacra 1 and 4 *Sarsiaster griegii* Mortensen
23. Anterior pore series of anterior unpaired petals quite rudimentary, giving appearance of half petal; four genital pores *Agassizia excentrica* A. Agassiz
23. Anterior pore series of anterior unpaired petals well developed, forming distinct petal; two or four genital pores 24
24. Two genital pores 25
24. Four genital pores (anterior genital pores often smaller) 26
25. Petals very deeply sunken, nearly closed; peripetalous fasciole following margins of paired petals *Moira atropos* (Lamarck)
25. Petals sunken but not nearly closed; peripetalous fasciole indented at interambulacra 1 and 4 but not following margins of paired petals *Schizaster orbignyianus* A. Agassiz
26. Periproct height greater than 19 percent TL; labrum length less than 10 percent TL; valves of globiferous pedicellariae terminating in two teeth *Paraster floridiensis* (Kier and Grant)
26. Periproct height less than 19 percent TL; labrum length greater than 10 percent TL; valves of globiferous pedicellariae terminating in more than two small teeth *Paraster doederleini* Chesher

Remarks: The type material for *P. doederleini* may include two species (Kier, 1975). The holotype from Florida has relatively longer anterior and posterior paired petals, a wider frontal ambulacrum, and more divergent posterior paired petals than the paratypes from Colombia. Kier (1975) did not describe the paratypes as a new species because he was not sure whether the differences vary along a geographical cline.

Family Schizasteridae Lambert, 1905

Schizaster orbignyianus A. Agassiz, 1880

Figure 37

Schizaster orbignyianus A. Agassiz, 1880, p. 84; 1883, p. 76, pl. 28, figs. 1-7; Rathbun, 1886, p. 292; H. L. Clark, 1917, p. 193; 1941, p. 126; Mortensen, 1951b, p. 306, pl. 23, figs. 4-6, 10; A. H. Clark, 1954, p. 375; Dawson, 1966, p. 178; Roa, 1967, p. 306, fig. 27.

Material examined: HOURGLASS STATION C: 1, 25.0 mm; 31 August 1966; dredge; FSBC I 11069. — 1, 6.5 mm; 21 June 1967; dredge; FSBC I 11070. — adult fragment; 21 November 1967; trawl; FSBC I 11072. — HOURGLASS STATION D: dead test fragment; 9 November 1966; dredge. — adult fragments; 2 July 1967; trawl; FSBC I 6776. — dead test fragment; 1 September 1967; trawl. — HOURGLASS STATION E: dead test fragment; 12 May 1967; dredge. — dead test fragment; 6 October 1967; trawl. — HOURGLASS STATION L: dead test fragment; 15 November 1967; dredge; FSBC I 11071.

Diagnosis: Test high, apex posterior; frontal ambulacrum (III) deeply sunken, wide, with pore-pairs arranged in single regular series on both sides; posterior interambulacrum raised to form marked keel behind

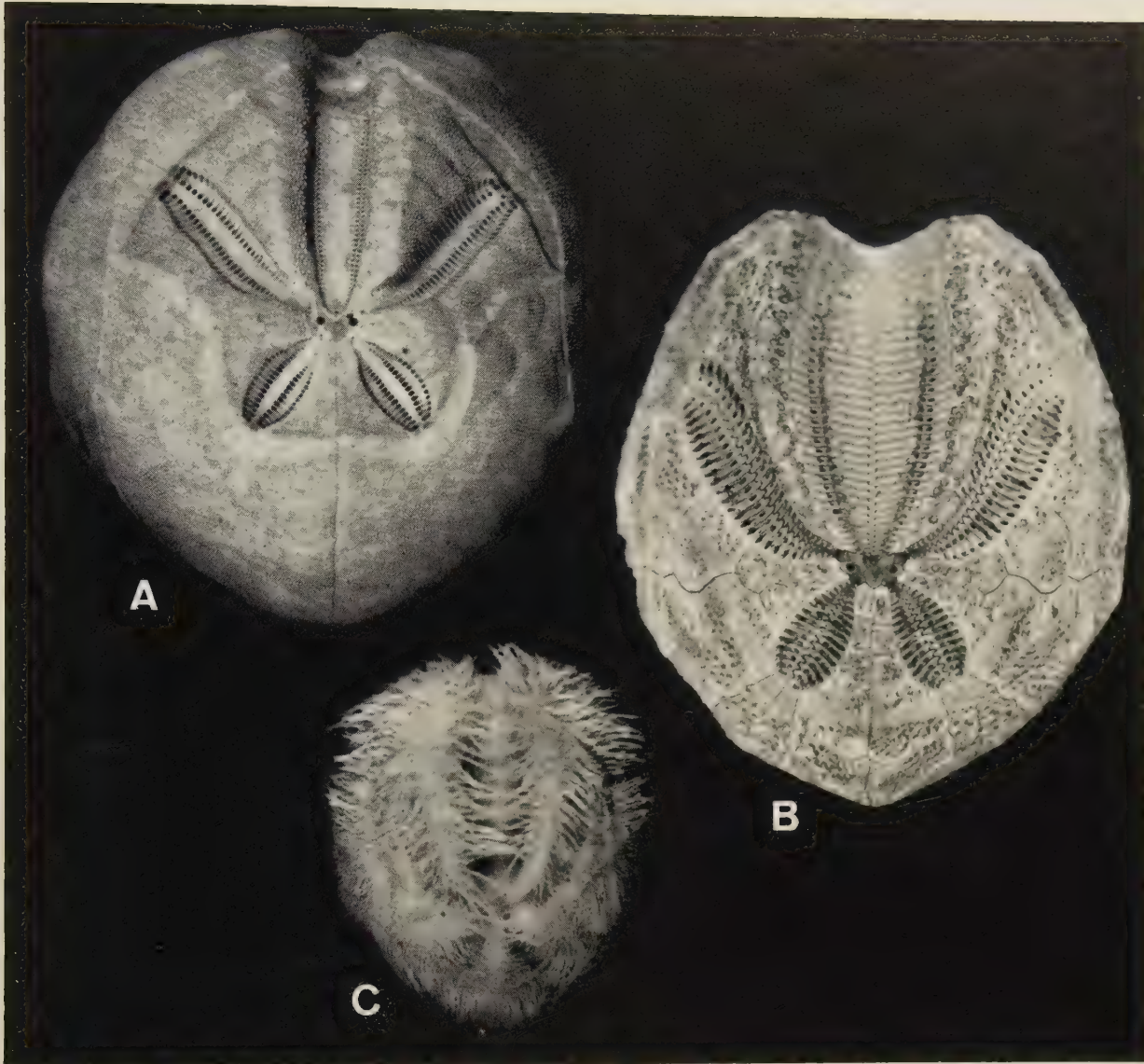


Figure 37: *Schizaster orbignyana*, aboral spect: A, cleaned test, 82 mm TL; Tortugas shrimp grounds; FSBC I 6462; B, cleaned test, 27 mm TL; off Surinam, 28 m; USNM E14278; C, 31 mm TL; Dry Tortugas, 46-53 m; FSBC I 4808.

apical system; lateroanal fasciole distinct; two genital pores; petals deeply sunken but not nearly closed; peripetalous fasciole indented at interambulacra 1 and 4 but not so much as to follow margins of paired petals.

Distribution: *Schizaster orbignyana* is known from Cape Cod, Massachusetts southward to the Bahamas and Cuba and in the eastern Gulf of Mexico from Louisiana to southern Florida. It occurs along the South American coast from Maracaibo, Venezuela to French Guiana and in the Lesser Antilles as far north as Barbados. Hourglass specimens were only obtained at Stations C and D, although dead tests were found at Stations E and L. It occurs in depths from 26 to 500 m but is most common from 75 to 300 m.

Bottom type: Hourglass specimens were collected from bottoms of crushed shell and algal sand (*Lithothamnion* spp.) at Stations C, D, E and L.

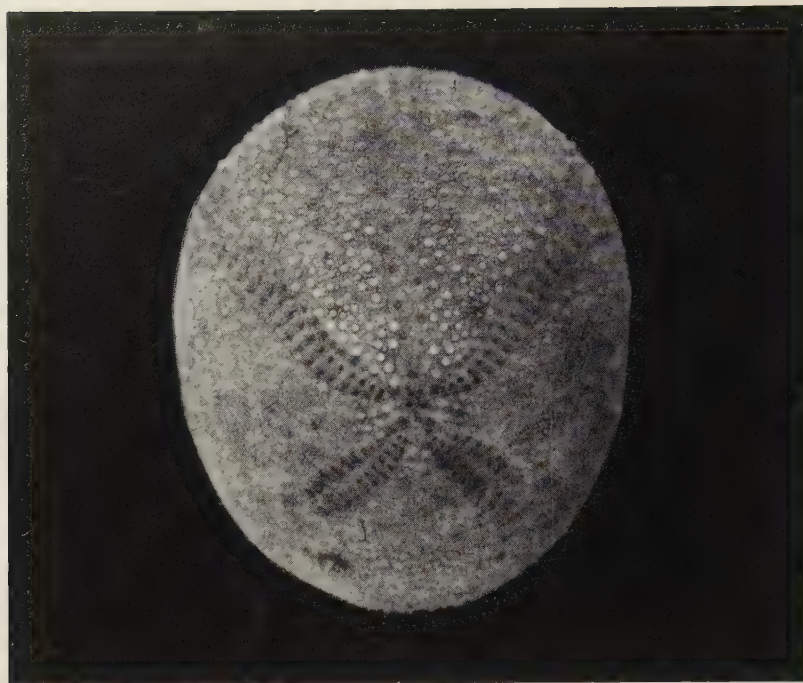


Figure 38. *Agassizia excentrica*, aboral aspect, 17 mm TL; Station M, February 1966; FSBC I 6669.

Agassizia excentrica A. Agassiz, 1869

Figure 38

Agassizia excentrica A. Agassiz, 1869, p. 276; 1872, pp. 88, 353, pl. 11, figs. 23, 24; 1880, p. 83; 1883, p. 71, pl. 25; Rathbun, 1885, p. 616; A. Agassiz, 1904, p. 198, text-figs. 285-287, pl. 108; H. L. Clark, 1917, p. 164; 1921, p. 120; Mortensen, 1951b, p. 345, pl. 55, figs. 5, 6, 8; A. H. Clark, 1954, p. 375; Lewis, 1963, p. 361.

Material examined: HOURGLASS STATION M: 1 dead test, 16.6 mm; 15 February 1966; trawl; FSBC I 6669.

Diagnosis: Test small, egg-shaped; lateroanal fasciole present; four genital pores; anterior pore series of anterior paired petals quite rudimentary, giving appearance of only half petal.

Distribution: *Agassizia excentrica* occurs from Cape Canaveral, Florida southward through the Greater and Lesser Antilles and along the Central and South American coast from Yucatan, Mexico to Surinam; in the Gulf of Mexico, it occurs off Florida as far north as Ft. Myers, and on the Campeche Banks off Yucatan, Mexico. It is known from 43 to 900 m, but is most common from 75 to 300 m. This specimen represents a northern range extension in the Gulf of Mexico. Since this species is fragile, and the specimen was complete, it could not have been dead for very long. The record is therefore considered valid even though based on a dead test.

Bottom type: The specimen from Station M was collected on a bottom of algal sand (*Lithothamnion* spp.).

Diet: Lewis (1963) reported that stomachs of five specimens from 180-200 m depths off Barbados contained coarse and fine sand or mud, tests of foraminifera and small gastropods. The species appeared to ingest loose bottom material at random.

Remarks: Agassiz (1880) stated that fragments indicate this species attains a size of two inches (ca. 50 mm). However, after examining hundreds of specimens in various museums, I have never seen a specimen greater than about 25 mm TL.



Figure 39. *Moira atropos*, aboral aspects: A, 55 mm TL; Eagle Harbor, northwest Florida, 2-3 m; FSBC I 18978; B, cleaned test, 26 mm TL; Station A, February 1966; FSBC I 1880.

Moira atropos (Lamarck, 1816)

Figure 39

Spatangus atropos Lamarck, 1816, p. 32.

Moera atropos: A. Agassiz, 1869, p. 278.

Moira atropos: A. Agassiz, 1872, pp. 146, 365, pl. 23; Cary, 1906, p. 52; H. L. Clark, 1917, p. 196; 1933, p. 89; Tortonese, 1933, p. 161; H. L. Clark, 1942, p. 383; Behre, 1950, p. 10; Mortensen, 1951b, p. 329, pl. 19, figs. 15, 20, pl. 55, figs. 11, 16, 19-23; A. H. Clark, 1954, p. 375; Mayr, 1954, p. 5; Chesher, 1963, p. 549, text-figs. 1-11; Moore and Lopez, 1966, p. 648; Tommasi, 1966b, p. 19, text-figs. 40, 88, pl. 5a; Randall, 1967, p. 723; Roa, 1967, p. 306, fig. 28; Stokes et al., 1968, p. 15; Godcharles, 1971, p. 27; Menzel, 1971, p. 86; Chesher, 1972, p. 152; Jolley, 1972, p. 37; Godcharles and Jaap, 1973, p. 54.

Material examined: HOURGLASS STATION A: 8, 22.7-23.9 mm; 3 August 1965; dredge; FSBC I 649. — 1, 37.2 mm; 3 January 1966; dredge; FSBC I 1506. — 1, 27.1 mm; 7 February 1966; dredge; FSBC I 1880. — 4, 31.1-36.3 mm; 1 December 1966; dredge. — 10, 17.4-24.0 mm; 1 August 1967; dredge; FSBC I 6870. — 2, 24.1, 26.7 mm; 31 August 1967; trawl; FSBC I 6775. — adult fragments; 5 October 1967; trawl. — adult fragments; 5 October 1967; dredge. — HOURGLASS STATION B: adult fragment; 18 October 1966;

dredge. — HOURGLASS STATION J: 1, 34.2 mm; 6 December 1966; dredge; FSBC I 6057. — adult dead test fragment; 7 April 1967; trawl.

Diagnosis: Test high, apex posterior; frontal ambulacrum (III) deeply sunken, narrow; paired petals deeply sunken, nearly closed at top, particularly adapically; posterior portion of test truncate; lateroanal fasciole distinct; peripetalous fasciole indented sharply on interambulacra to follow margins of paired petals; two genital pores.

Distribution: *Moira atropos* occurs from Cape Hatteras, North Carolina and Bermuda southward through the Greater and Lesser Antilles and along the coasts of the Gulf of Mexico and Central and South America to São Paulo, Brazil. It occurs in depths from 0 to 445 m but is more commonly found in less than 50 m. Chesher (1963) stated it is most common in depths of 3 to 6 m.

Bottom type: *Moira atropos* occurs in mud or hard sand bottoms where adults burrow down to 15 cm. Moore and Lopez (1966) found it most abundant in sediments ranging from 75 to 90 percent sand, while Chesher (1963) reported it most abundant in soft, liquid mud where concentrations reached 32/m². Hourglass specimens were collected at nearshore stations on bottoms of quartz sand with some crushed shell.

Diet: *Moira atropos* feeds primarily on detritus, extending the tube feet of ambulacrum III through a tunnel extending to the surface of the substrate and using these podia to sweep detritus down the tunnel (Chesher, 1963). Detritus is incorporated into a feeding mucus rope and is passed into the mouth by the oral tube feet. Substrate from below the surface is also ingested. It adheres to the mucus on the oral tube feet and is deposited in the mouth by whisking the tube feet across the oral rakers.

Growth and reproduction: Moore and Lopez (1966) found that specimens from Biscayne Bay, Florida reached a size of 12 mm TL after one year, 30 mm after two years, and 38 mm after three years. They also noted an inverse relationship between rate of test growth and water temperature. Similar inverse relationships were found by Moore and McPherson (1965) for *Lytechinus variegatus* and *Tripneustes ventricosus* (Lamarck, 1816) [= *esculentus* (A. Agassiz, 1872)] from the same area. *Moira atropos* is an infaunal species and is buffered from rapid temperature changes in overlying water. It is therefore not surprising to note that the slope of the inverse relationship is much less than Moore and McPherson (1965) found for the epifaunal *L. variegatus* and *T. ventricosus*. Chesher (1963) found *M. atropos* as large as 58 mm TL; these specimens were presumably older than three years.

Moore and Lopez (1966) found that spawning generally occurs in specimens two or more years old and only occasionally occurs in individuals one year old. Spawning occurred in Biscayne Bay during April 1964 and March 1965. They found a significant correlation between spawning and lunar phases, with peak spawning occurring just after a full moon.

Population dynamics: A mortality rate of about 57 percent per year was calculated by Moore and Lopez (1966) from four years of data from Biscayne Bay, and the rate did not change with increasing age. They calculated a mean concentration of adult *M. atropos* (one to four years old) for all populations studied in Biscayne Bay for all seasons to be about 10/m². From this, a total productivity of 3.61 g dry weight of tissue per square meter per year was calculated, of which, 1.09 g was in the form of spawn (Moore and Lopez, 1966).

Morphometric and meristic relationships: Six measurements and three counts were taken on 17 *M. atropos* from 18 to 38 mm TL. Table 26 shows linear regression data for various characters as a function of TL. Characters that did not change as a function of size were IA (8.0 ± 0 plates) and OPAMB (8.12 ± 0.33 plates).

TABLE 26. LINEAR REGRESSION DATA FOR VARIOUS CHARACTERS
AS A FUNCTION OF TL IN *M. ATROPOS**.

Character	Regression Equation	$s_{y.x}$	r
TW	$y = 0.84x + 0.56$	0.34	1.00
TH	$y = 0.79x - 1.12$	0.66	0.99
PH	$y = 0.16x + 0.019$	0.21	0.98
PW	$y = 0.094x + 0.55$	0.15	0.97
PSW	$y = 0.19x + 0.24$	0.30	0.97
PAMB	$y = 0.24x + 13.77$	0.72	0.91

*All characters (ordinates) plotted as function of TL (abscissa). All measurements in mm; $s_{y.x}$ = standard deviation of y for fixed x; r = correlation coefficient of linear regression line. N = 17.

Predators: *Luidia clathrata* (Say, 1825), a sea star, is a predator of *M. atropos*; one Hourglass *Moira* was obtained from the stomach of that sea star. Randall (1967) found this species in the stomach contents of the margate, *Haemulon album*.

Family Brissidae Gray, 1855

Brissopsis atlantica Mortensen, 1907

Figure 40



Figure 40. *Brissopsis atlantica*, aboral aspect, 57 mm TL; Gulf of Mexico, 27°52'N, 92°55'W, 192 m; USNM E15580.

Brissopsis atlantica Mortensen, 1907, p. 160, pl. 3, figs. 6, 10, 17, pl. 18, figs. 5, 9, 10, 13, 19, 20, 24, pl. 19, figs. 1, 4, 5, 11, 25, 28, 32, 33; H. L. Clark, 1917, p. 203; 1941, p. 126; Mortensen, 1951a, p. 301, pl. 1, fig. 4, pl. 2, figs. 1, 2; 1951b, p. 415, pl. 31, fig. 11, pl. 59, fig. 7; A. H. Clark, 1954, p. 375; Tommasi, 1966b, p. 19, pl. 9a; Chesher, 1968a, p. 43, pls. 6-14.

Material examined: HOURGLASS STATION C: 1, 19.8 mm; 31 August 1966; dredge; FSBC I 4456. — HOURGLASS STATION D: 1, 29.1 mm; 21 June 1967; dredge; FSBC I 6471. — HOURGLASS STATION M: 3, 22.0-33.6 mm; 7 August 1965; dredge; FSBC I 4449.

Diagnosis: Subanal fasciole reniform; peripetalous fasciole present; width of ambulacrum I or V on oral surface greater than 40 percent greatest width of plastron; labrum extending posteriorly to first adjoining ambulacral plates; posterior petals (I and V) confluent proximally, divergent distally; five ambulacral plates (rarely four) entering subanal fasciole; peripetalous fasciole frequently dipping down to plate 4b in interambulacrum 3.

Distribution: *Brissopsis atlantica* occurs from Cape Hatteras, North Carolina southward along the Gulf coast and the Caribbean coasts of Central and South America to French Guiana and throughout the Greater and Lesser Antilles. It occurs in depths from 26 to 641 m but is most common from 50 to 200 m.

Bottom type: According to Chesher (1968a), the species lives buried in a wide variety of mud substrates. Specimens in this study were found at offshore stations on bottoms of algal sand (*Lithothamnion* spp.) and crushed shell.

Meoma ventricosa ventricosa (Lamarck, 1816)

Figure 41

Spatangus ventricosus Lamarck, 1816, p. 29.

Brissus ventricosus: Gray, 1825, p. 431.

Meoma ventricosa: A. Agassiz, 1872, pp. 143, 358, pl. 20, fig. 8, pl. 22, figs. 3, 4, pl. 26, figs. 31-34, pl. 38, figs. 24, 25; Bell, 1879, p. 253; Rathbun, 1885, p. 616; H. L. Clark, 1917, p. 221; 1918, p. 37; 1933, p. 92; Tortonese, 1933, p. 167; H. L. Clark, 1941, p. 127; Mortensen, 1951b, p. 529, pl. 36, fig. 1, pl. 52, figs. 1, 6, 15; A. H. Clark, 1954, p. 375; Mayr, 1954, p. 6; Kier and Grant, 1965, p. 38, pl. 3, figs. 4, 5, pl. 9, figs. 1-4, pl. 10, figs. 1-4, pl. 11, figs. 1-6, pl. 12, figs. 1-4, pl. 13, figs. 1-3, pl. 15, fig. 6, pl. 16, figs. 5, 6; Kier, 1966, p. 8, pl. 2, figs. 1-3; Tommasi, 1966b, p. 20, pl. 8a; Roa, 1967, p. 307; Chesher, 1969, p. 72, text-figs. 2-14; Godcharles and Jaap, 1973, p. 54; Burke, 1974, p. 317, fig. 15; Hopkins et al., 1977, p. 35.

Meoma ventricosa ventricosa: Chesher, 1970, p. 737, text-figs. 2-5; 1972, p. 152.

Material examined: HOURGLASS STATION A: dead test fragments; 5 February 1967; dredge. — HOURGLASS STATION C: 3, 155-165 mm; 8 November 1965; dredge. — 2, 160, 170 mm; 8 November 1965; trawl. — 3, 180-200 mm; 18 July 1966; trawl. — 1, 172 mm; 14 March 1967; dredge; FSBC I 6799. — fragments; 20 May 1967; dredge. — fragments; 11 August 1967; dredge. — 1, 91 mm; 31 August 1967; trawl; FSBC I 6778. — fragments; 25 October 1967; dredge. — 3, 123-143 mm; 2 November 1967; dredge. — fragments; 2 November 1967; trawl. — HOURGLASS STATION D: 4, 135-145 mm; 4 December 1965; dredge. — 1, 158 mm; 4 December 1965; trawl. — 1, 170 mm; 21 February 1966; dredge. — 4, 142-148 mm; 7 April 1966; dredge. — 1, 152 mm; 7 April 1966; trawl. — 1, 145 mm; 7 June 1966; dredge. — 1, 150 mm; 18 June 1966; dredge. — 2, 143, 147 mm; 3 July 1966; dredge. — 2, 139, 149 mm; 11 July 1966; trawl. — 1, 134 mm; 11 July 1966; dredge. — 6, 142-154 mm; 2 August 1966; trawl. — 4, 138-165 mm; 2 August 1966; dredge. — 1, 152 mm; 9 October 1966; dredge. — 1 adult; 9 November 1966; dredge. — dead test fragments; 14 December 1966; trawl. — fragment; 14 December 1966; dredge. — 1, 157 mm; 28 February 1967; dredge; FSBC I 6798. — fragments; 12 May 1967; dredge. — fragments; 21 May 1967; dredge. — 2, 149 mm, adult fragment; 3 June 1967; dredge. — fragments; 21 June 1967; dredge. — 1 adult; 12 July 1967;



Figure 41. *Meoma ventricosa ventricosa*, aboral aspects: A, 171 mm TL; Station C, March 1967; FSBC I 6799; B, cleaned test, 144 mm TL; data unknown.

dredge. — 1 adult; 2 August 1967; trawl. — 1 adult; 2 August 1967; dredge. — fragments; 12 September 1967; dredge. — 3, 141 mm, (2 broken); 6 October 1967; dredge. — HOURGLASS STATION K: 1, 143 mm; 4 September 1965; dredge; FSBC I 878. — 1, 147 mm; 21 March 1966; trawl. — 3, 145-156 mm; 21 March 1966; dredge. — 5, 148-157 mm; 12 June 1966; trawl. — 15, 142-153 mm; 12 June 1966; dredge. — fragments; 6 December 1966; dredge. — 6, 160-167 mm; 5 July 1967; dredge. — HOURGLASS STATION L: 1 adult; 7 August 1965; dredge. — 2, 135, 142 mm; 4 September 1965; dredge. — 10, 110-157 mm; 13 October 1965; dredge; FSBC I 946. — 4, 154-170 mm; 13 November 1965; trawl. — 8, 130-160 mm; 13 November 1965; dredge. — 1, 140 mm; 7 December 1965; dredge. — 2, 151, 160 mm; 13-14 December 1965; trawl. — 8, 142-162 mm; 13-14 December 1965; dredge. — 11, 130-146 mm; 14 January 1966; trawl. — 6, 140-154 mm; 14 January 1966; dredge. — 15, 149-163 mm; 15 February 1966; trawl. — 8, 141-165 mm; 15 February 1966; dredge. — 13 adults; 22 March 1966; trawl. — 20, 136-147 mm; 22 March 1966; dredge. — 33, 138-158 mm; 12 April 1966; trawl. — 15, 141-153 mm; 12 April 1966; dredge. — 2, 150 mm, adult fragment; 12 May 1966; trawl. — 24 adults; 12 May 1966; dredge. — 13 adults; 13 June 1966; trawl. — 13, 126-149 mm; 13 June 1966; dredge. — 9, 130-144 mm; 6 July 1966; trawl. — 15, 124-144 mm; 6 July 1966; dredge. — 3, 139-164 mm; 22 July 1966; trawl. — 4, 137-161 mm; 6 August 1966; trawl. — 6, 128-147 mm; 6 August 1966; dredge. — 10, 137-150 mm; 5 September 1966; dredge. — 8, 134-143 mm; 13 October 1966; dredge. — 20, 142-161 mm; 13 November 1966; dredge. — 2, 153 mm, adult fragment; 7 December 1966; trawl. — 10, 148-149 mm; 7 December 1966; dredge. — 7 adults; 13 January 1967; trawl. — 2, 152, 153 mm; 13 January 1967; dredge. — 3, 133-144 mm; 31 January 1967; trawl. — 3, 151-154 mm; 16 February 1967; trawl. — 6, 135-154 mm; 16 February 1967; dredge. — 9, 132-160 mm; 9 March 1967; dredge; FSBC I 11105. — 8 adults; 8 April 1967; trawl. — 8, 120-158 mm; 8 April 1967;

Growth and reproduction: This urchin reaches a size of 88 mm TL in one year, 120 mm in two years, 130 mm in three years, and 134 mm in four years (Chesher, 1969). This growth rate refers to populations living in sandy patches within shallow *Thalassia* beds. Chesher pointed out that individuals from siltier habitats do not grow as large and that specimens from open sand areas or deeper water grow to a larger size. In this study, specimens from offshore stations (C, D, K and L) were commonly larger than 160 mm TL, and one specimen was 200 mm TL.

Spawning occurs from August to February, with peak spawning occurring from November to January (Chesher, 1969). Genital pores appear in specimens from 39 to 52 mm TL, but, according to Chesher, gonads do not mature until about 90 mm TL. He found that spawning did not generally occur until the second year.

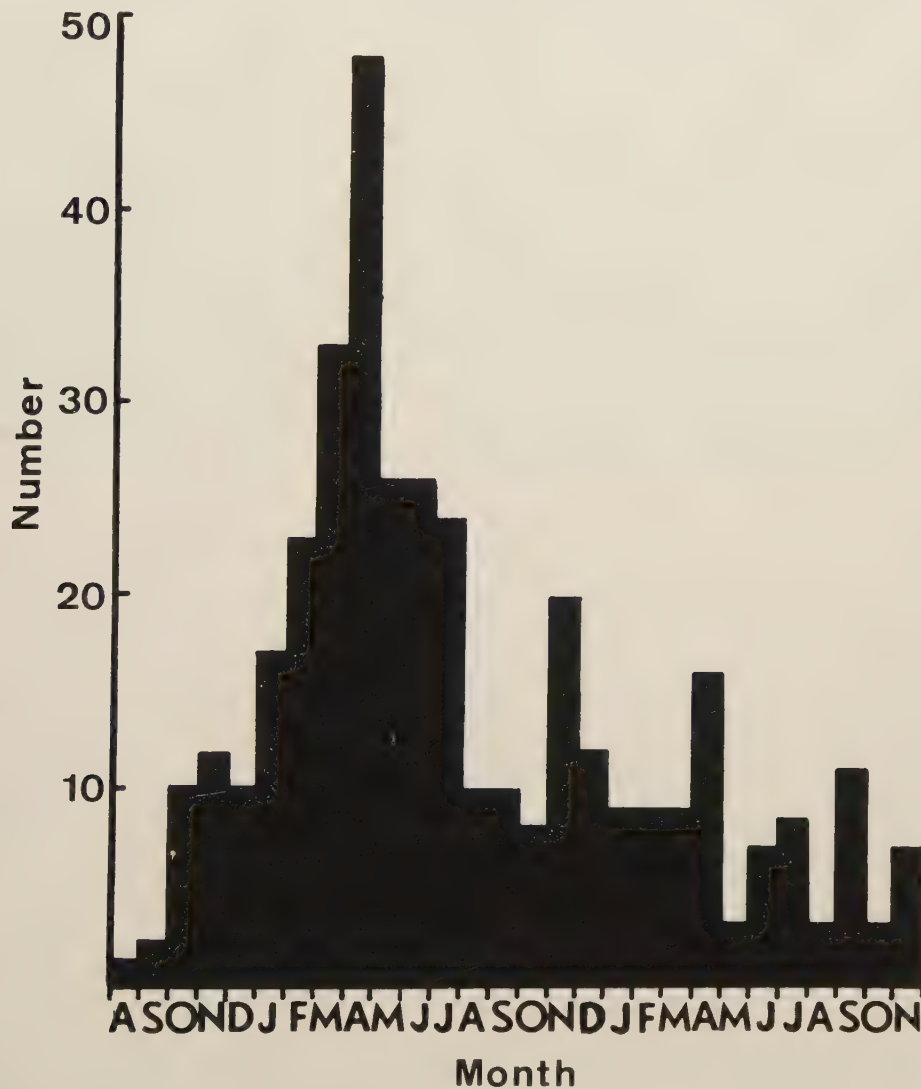


Figure 42. Seasonal abundance of *M. ventricosa ventricosa*, Station L, August 1965-November 1967.

Population dynamics: Seasonal abundance of *M. v. ventricosa* at Station L from August 1965 through November 1967 is depicted in Figure 42. A very small population was present during 1965. During 1966 the population increased continually until May, after which it continually decreased until the end of the study (November 1967). The smallest specimen collected was 91 mm TL and the next smallest was 123 mm TL. Thus, all specimens were adults. It is apparent from Chesher's (1969) growth data that none of the specimens

were less than one year old. According to Chesher, young specimens are found buried 5 to 8 cm in sand, often under slabs of coral. He stated that young individuals were not commonly found emerging at night until they reached a size of about 100 mm TL, probably explaining why only large specimens were collected during this study.

Gear selectivity: The dredge collected nearly twice as many specimens as the trynet, with 315 and 162 specimens collected, respectively.

Morphometric and meristic relationships: Chesher (1970) did a complete morphometric and meristic survey of this genus, and Kier and Grant (1965) did a similar but less extensive study of *M. v. ventricosa*. Kier and Grant (1965) described several changes occurring with growth from juveniles to adults. The test becomes lower, more angular petals become depressed, and posterior truncation tilts so that the periproct is visible adorally. The posterior petals become much longer, and all petals become relatively narrower and curved at their ends. The peristome becomes smaller relative to length of the test, and the labrum enlarges and extends anteriorly. Spines become more equal in size and proportionately much shorter. The subanal fasciole becomes discontinuous because of elimination of that portion of the fasciole nearest the periproct. Genital pores develop between 40 and 60 mm TL.

Predators and commensals: The sea star, *Oreaster reticulatus* (Linné, 1758), and the red banded parrot fish, *Sparisoma aurofrenatum* (Valenciennes), are listed as predators of *M. v. ventricosa* by Kier and Grant (1965). According to Chesher (1969), a small pinnotherid crab, *Dissodactylus* sp., is found associated with almost all large *M. v. ventricosa*.

Plagiobrissus grandis (Gmelin, 1788)

Figure 43

Echinus grandis Gmelin, 1788, p. 3200.

Spatangus pectoralis Lamarck, 1816, p. 29.

Plagionotus pectoralis: A. Agassiz, 1869, p. 275.

Metalia pectoralis: A. Agassiz, 1872, pp. 144, 361, pl. 21, figs. 4, 5; 1881, p. 199.

Plagiobrissus grandis: H. L. Clark, 1917, p. 207, pl. 146, figs. 21, 22; 1933, p. 90; Tortonese, 1933, p. 163; Mortensen, 1951b, p. 496, pls. 40, 41, pl. 63, figs. 13, 16; A. H. Clark, 1954, p. 375; Hildebrand, 1955, p. 196; Moore, 1956, p. 74; Kier and Grant, 1965, p. 36, pl. 8, figs. 1-6, pl. 15, figs. 2, 3; Tommasi, 1966b, p. 20, pl. 5b; Menzel, 1971, p. 86; Chesher, 1972, p. 153; Jolley, 1972, p. 37; Godcharles and Jaap, 1973, p. 54.

Material examined: HOURGLASS STATION B: dead test fragment; 2 March 1967; trawl. — dead test fragment; 31 August 1967; trawl. — dead test fragment; 11 September 1967; trawl. — 1, 6.5 mm; 5 October 1967; dredge; FSBC I 6628. — HOURGLASS STATION C: 1 juvenile; 6 November 1966; dredge; FSBC I 6856. — adult fragment; 2 March 1967; dredge; FSBC I 6773. — fragment; 11 July 1967; dredge. — fragment; 11 August 1967; dredge. — juvenile fragment; 2 November 1967; trawl. — HOURGLASS STATION I: 1 adult; 21 March 1966; dredge. — HOURGLASS STATION J: 1, 33.5 mm; 6 December 1966; dredge; FSBC I 6056. — HOURGLASS STATION K: 1, 62.0 mm; 12 October 1966; trawl; FSBC I 4806. — 1, 60.0 mm; 12 January 1967; dredge; FSBC I 11106. — fragment; 15 February 1967; trawl. — 1, 46.3 mm; 7 April 1967; dredge. — adult fragment; 14 November 1967; dredge. — HOURGLASS STATION L: dead test fragment; 13 November 1966; trawl. — dead test fragment; 6 July 1967; trawl.

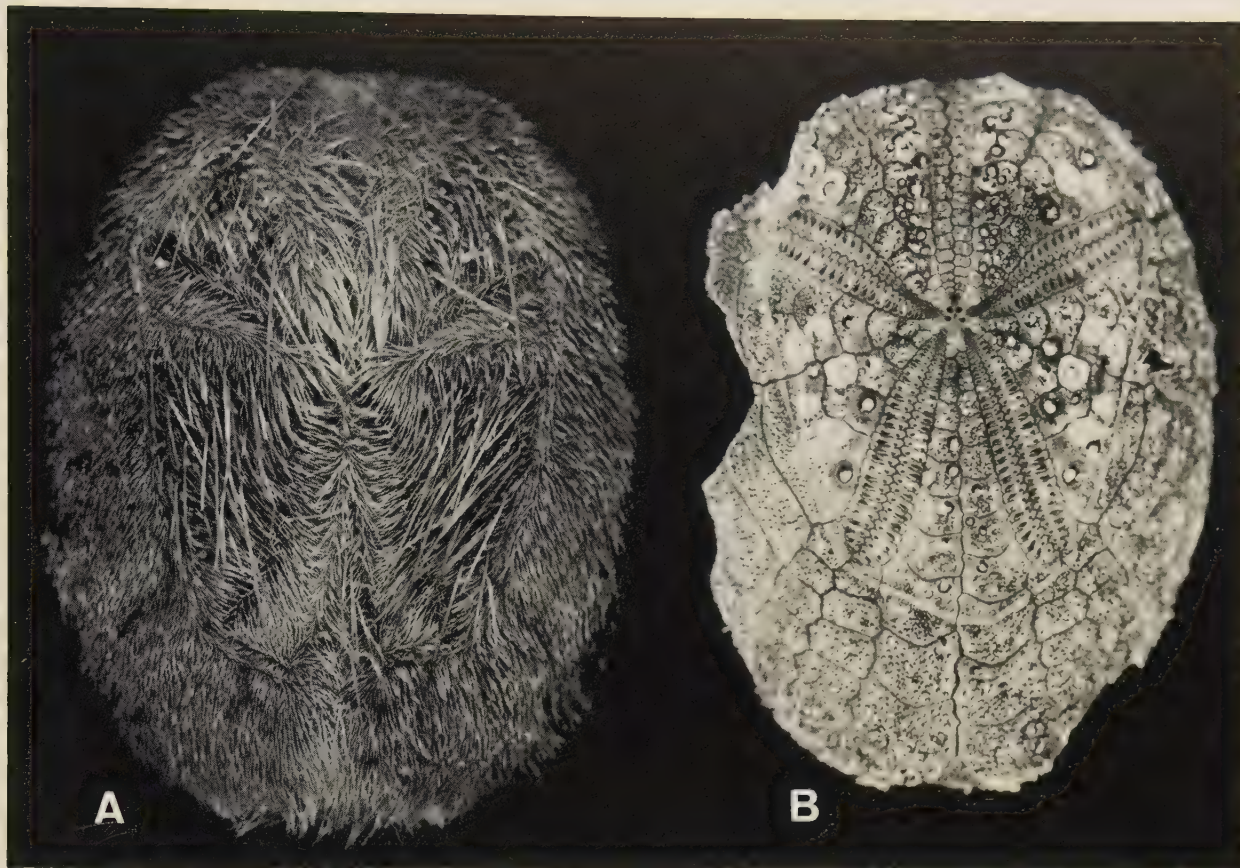


Figure 43. *Plagiobrissus grandis*, aboral aspects: A, 140 mm TL; west northwest of Clearwater, Florida west coast, 14 m; FSBC I 5707; B, approximately 57 mm TL; Station K, January 1967; FSBC I 11106.

Diagnosis: Large forms up to 220 mm TL; test fragile, low, height generally less than 30 percent TL; subanal fasciole shield-shaped; peripetalous fasciole present; slight frontal depression present at ambitus in ambulacrum III; large primary tubercles within peripetalous fasciole; four genital pores.

Distribution: *Plagiobrissus grandis* is known from Cape Canaveral, Florida and the Bahama Islands southward throughout the Greater and Lesser Antilles. It is known along the entire Gulf coast and along the Central and South American coasts to São Paulo, Brazil. It occurs in depths from 1 to 210 m but is most common in less than 50 m.

Bottom type: According to Kier and Grant (1965), this species is found buried about 5 cm in sandy areas where seagrass and algae are sparse or absent. Hourglass specimens were found on bottoms of crushed shell and quartz sand.

Predators: This species is preyed upon by the large helmet conch, *Cassis* (Moore, 1956). Kier and Grant (1965) observed rates of movement up to 10 cm per second. Chesher (personal communication) has observed that nearly all dead tests drilled by a gastropod were drilled anteriorly. Since *P. grandis* is very mobile but can only move forward, it is probable that most specimens caught by *Cassis* were approached from the front and not from behind. A juvenile *P. grandis* was found in the stomach of a sea star, *Luidia alternata*, from Hourglass Station C.



Figure 44. *Echinocardium laevigaster*, aboral aspect, 24 mm TL; Station M, August 1965; FSBC I 3563.

Family Loveniidae Lambert, 1905

Echinocardium laevigaster A. Agassiz, 1869

Figure 44

Echinocardium laevigaster A. Agassiz, 1869, p. 277; H. L. Clark, 1917, p. 264; Mortensen, 1951b, p. 161; A. H. Clark, 1954, p. 375.

Material examined: HOURGLASS STATION M: 1, 24.4 mm; 7 August 1965; dredge; FSBC I 3563.

Diagnosis: Small, fragile forms, generally less than 40 mm TL; inner fasciole present; subanal fasciole present; four genital pores; primary tubercles aborally, generally confined to interambulacra 2 and 3.

Distribution: *Echinocardium laevigaster* is known from Cape Hatteras, North Carolina southward around the tip of Florida and into the Gulf of Mexico as far north as off Ft. Myers, Florida. It occurs in depths from 40 to 220 m. This specimen represents a northern range extension in the Gulf of Mexico.

Bottom type: The specimen from Station M was collected on a bottom composed primarily of algal sand (*Lithothamnion* spp.).

DISCUSSION

STATION AND SPECIES ASSOCIATIONS

Bathymetric ranges for echinoids are frequently quite wide, but specimens establishing these limits are often from relict populations where reproduction is poor or absent. Occasionally the extremes of these ranges are established by a single specimen which, as a result of a unique set of physical or biological conditions, is found tens or hundreds of meters shallower or deeper than other members of its species. These ranges are then published with no qualifications, giving distorted impressions of echinoid bathymetric ranges. For example, *Arbacia punctulata* is known from depths ranging from 0 to 225 m, but trying to collect it in depths greater than approximately 50 m would be unproductive. This can be seen in Figure 13, where specimens from offshore Hourglass Stations D, E, L and M were few in number, and all were juveniles. A better way to describe the bathymetric distribution of *A. punctulata* is to state that it is known from 0 to 225 m but occurs most commonly in less than 50 m. Hourglass species and numbers of specimens collected at each station are listed in Table 28. In addition to known bathymetric ranges, a common occurrence depth range is given. These more restricted depth ranges are entirely subjective and based on unpublished data from D. K. Serafy and F. J. Fell, but they provide a more simplified representation of species distributions. It is apparent from these preferred depth ranges that there are species which can be considered shallow-water or inner-shelf species. These species generally occur in less than 50 m, but some species, such as *M. quinquiesperforata*, may have a shallower preference (≤ 30 m), or some, such as *M. v. ventricosa*, may have a slightly deeper preference (≤ 60 m). The inner shelf species group includes *E. t. tribuloides*, *D. antillarum*, *A. punctulata*, *L. v. carolinus*, *C. subdepressus*, *M. quinquiesperforata*, *E. aberrans*, *E. michelini*, *M. atropos*, *M. v. ventricosa* and *P. grandis*. Most of the remaining Hourglass species can be characterized as outer shelf species which commonly occur from 50 to 200 m, but some species are common in somewhat deeper water (75 to 300 m). This outer shelf group includes: *S. affinis*, *C. l. rubricingulus*, *C. floridanus*, *G. maculata*, *L. euerces*, *C. ravenelii*, *E. depressa*, *S. orbignyanus*, *A. excentrica*, *B. atlantica* and *E. laevigaster*. The remaining Hourglass species appear to occupy habitats along the middle depths of the continental shelf. However, these species are generally poorly known because they are rare (e.g., *A. magnifica*), recently described (e.g., *C. chesheri*) or historically confused with a similar species (*C. prostratus* was until recently commonly misidentified as *C. subdepressus*). As these species become better known, they could possibly fall within the outer shelf category. This type of analysis is subjective and based on a general knowledge of the echinoids throughout their geographic range. However, the Hourglass data provided in Table 28 quantifies the relative abundance of each species at each station, and these data were subjected to a cluster analysis. Rare species represented by one or two specimens were not included in the cluster analysis for statistical reasons. These rare species were *A. magnifica*, *C. floridanus*, *S. orbignyanus*, *A. excentrica* and *E. laevigaster*. The remaining 20 species clustered into one minor and two major groups (Figure 45). The heart urchin *M. atropos* had a unique distribution and was restricted to Station A except for one specimen collected at Station J. None of the Hourglass stations provided a good habitat for *M. atropos*, which prefers a silty-sand to muddy substrate (Chesher, 1963; Moore and Lopez, 1966). However, *M. atropos* can definitely be considered an inner shelf species and is rarely taken in depths greater than 50 m. The first major species cluster included eight echinoids which can also be considered inner shelf species. *Arbacia punctulata* and *L. v. carolinus* had a high incidence of co-occurrence and were abundant at Stations A, B, C, I, J and K. The sand dollar *M. quinquiesperforata* was very abundant at Station A and common at Stations B and I, while *E. michelini* and *E. aberrans* were restricted to Stations B and I, and B, J and K, respectively. *Plagiobrissus grandis* and *C. subdepressus* were most abundant at Stations C and K, but also occurred further inshore. *Diadema antillarum* is abundant on shallow, rocky substrates throughout the tropical western Atlantic and Caribbean Sea and was included in the inshore species cluster. However, populations within the Hourglass sampling region were small and restricted to the 37 m stations. This provides a good example of submergence of a tropical species into deeper waters in higher latitudes and is believed to be a result of the more stable temperature and salinity (Table 29) present offshore rather than a lack of appropriate

TABLE 28. DISTRIBUTION OF HOURGLASS ECHINOIDS.

Species	A I	B J	C K	D L	E M	Depth Range Commonly Found (m)	Known Depth Range (m)
<i>Eucidaris t. tribuloides</i>	0 0	0 0	4(6)* 1	2(2) 92	1 11	1-50	0-800
<i>Stylocidaris affinis</i>	0 0	0 0	0 31	2 51	152 182	50-200	23-1000
<i>Diadema antillarum</i>	0 0	0 0	8(5) 1	1 0	0 0	1-50	0-400
<i>Astropyga magnifica</i>	0 0	0 0	1 0	0 1	0 0	?	11-88
<i>Centrostephanus longispinus</i>	0	0	0	0	1	100-300	55-530
<i>rubricingulus</i>	0	0	0	3	2		
<i>Arbacia punctulata</i>	33 361	194(120) 523	105(91) 42	16(20) 31	3 2	1-50	0-225
<i>Coelopleurus floridanus</i>	0 0	0 0	0 0	0 0	0 1	100-300	73-530
<i>Genocidaris maculata</i>	0 0	0 0	16(8) 11	122(60) 206	121 348	50-200	12-420
<i>Lytechinus euerces</i>	0 0	0 0	0 0	2 1	2 1	75-300	55-550
<i>Lytechinus variegatus</i>	696	147(104)	117(49)	22(15)	0	1-50	0-75
<i>carolinus</i>	1044	47	13	27	5		
<i>Clypeaster chesheri</i>	0 0	0 0	0 0	0 0	0 5	?	20-101
<i>Clypeaster prostratus</i>	0 0	0(2) 0	26(3) 17	48(34) 17	1 1	?	15-75
<i>Clypeaster ravenelii</i>	0 0	0 0	0 0	3 0	9 17	75-200	50-230
<i>Clypeaster subdepressus</i>	0 3	8 1	22(3) 45	1 1	0 0	10-50	5-210
<i>Mellita quinquiesperforata</i>	37,612 94	28(4) 0	1 0	0 0	0 0	1-30	0-180
<i>Encope aberrans</i>	0 0	8(9) 15	0(1) 28	0 0	0 0	20-60	12-90
<i>Encope michelini</i>	0 6	236(88) 0	0 0	0 0	0 0	10-50	3-90
<i>Echinolampas depressa</i>	0 0	0 0	0 0	3(1) 27	5 16	50-200	37-310
<i>Schizaster orbignyanus</i>	0 0	0 0	1(2) 0	1 0	0 0	75-300	26-500
<i>Agassizia excentrica</i>	0 0	0 0	0 0	0 0	0 1**	75-300	43-900
<i>Moiria atropos</i>	30 0	0(1) 1	0 0	0 0	0 0	1-50	0-445
<i>Brissopsis atlantica</i>	0 0	0 0	1 0	0(1) 0	0 3	50-200	26-640
<i>Meoma v. ventricosa</i>	0 0	0 0	9(7) 32	33(11) 384	0 1	5-60	2-200
<i>Plagiobrissus grandis</i>	0 1	1 1	3(2) 5	0 0	0 0	10-50	1-210
<i>Echinocardium laevigaster</i>	0 0	0 0	0 0	0 0	0 1	?	40-220

*Numbers in parentheses represent specimens collected during Post HC cruises.

**Dead test only.

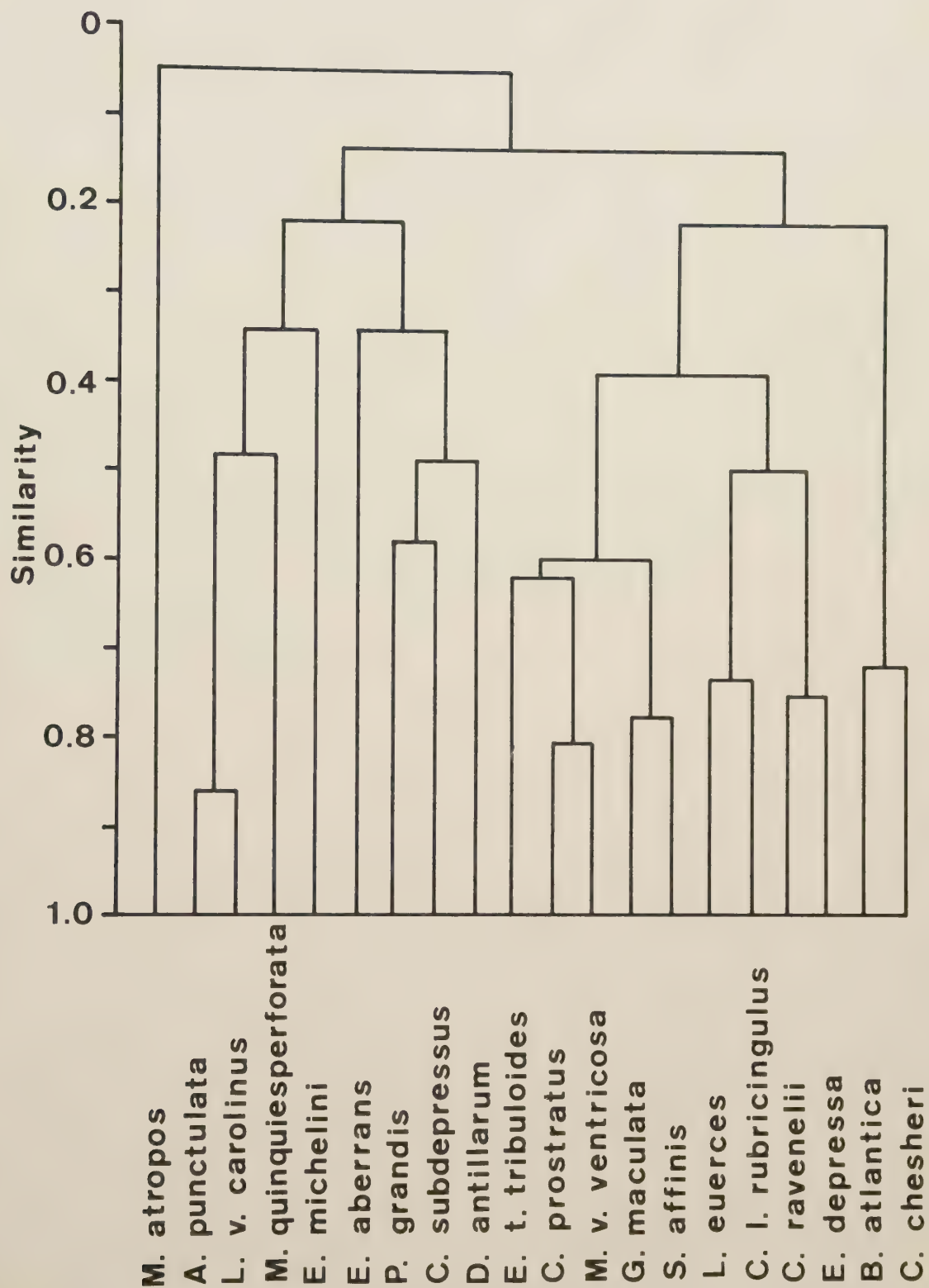


Figure 45. Echinoid faunal associations within the Hourglass study area, as indicated by similarities of species occurrence.

TABLE 29. RANGE OF BOTTOM TEMPERATURES AND SALINITIES
FOR BENTHIC HOURGLASS STATIONS FROM 1965-67.

Station	Depth (m)	Temperature (°C)	Salinity (‰)
(Northern Transect)			
A	6	11.3-31.5	29.80-36.18
B	18	13.9-30.0	31.22-36.33
C	37	15.8-25.5	32.26-36.51
D	55	16.8-25.0	32.54-36.60
E	73	17.5-26.0	32.65-36.55
(Southern Transect)			
I	6	15.5-31.0	30.24-36.47
J	18	16.4-30.0	32.84-36.30
K	37	18.0-28.0	33.66-36.45
L	55	18.5-26.0	33.92-36.71
M	73	17.2-25.6	33.94-36.67

substrate. Limestone outcroppings occurred at Stations B, J, C and K, but *D. antillarum* only occurred at the deeper Stations C, D and K. Avent et al. (1977) similarly reported diadematid urchins, apparently *D. antillarum*, restricted to warm Florida Current waters washing upper portions of submerged pinnacles off eastern Florida. Bases of the pinnacles below a distinct pycnocline at depths of about 75 m were devoid of urchins.

Eleven species clustered into an outer shelf species group. Within this group, there were five species which generally occurred at Stations C, D, E, K, L and M; these species included *G. maculata*, *C. prostratus*, *S. affinis*, *E. t. tribuloides* and *M. v. ventricosa*. *Eucidaris t. tribuloides* is most abundant in less than 50 m throughout most of its range and commonly occurs subtidally on rocky substrates. However, it never occurred shallower than 37 m within the Hourglass area, providing another good example of tropical submergence in higher latitudes. As was the case for *D. antillarum*, this is believed to be a result of the more stable environmental conditions present at Stations C and K, since the same rocky substrate preferred by this species occurs at shallower Stations B and J. Therefore, the clustering of *E. t. tribuloides* with the outer shelf species group is an artifact of tropical submergence within the Hourglass sampling region. Similarly, *M. v. ventricosa* is common from 5 to 60 m throughout most of its range, but within the Hourglass region it never occurred shallower than 37 m and was most abundant at 55 m. According to Chesher (1969), *M. v. ventricosa* has the greatest ecological diversity of all West Indian spatangoids, and it occurs on a variety of sediments ranging from fine, heavily silted sand to coral rubble. Its lack of sediment specificity should enable it to establish populations at the inshore sandy Stations A, B, I and J. However, the fact that it is restricted to deeper Stations C, D, K, L and M provides further evidence of the tropical nature of the offshore sediments off west Florida.

Lytechinus euerces, *C. l. rubricingulus*, *C. ravenelii* and *E. depressa* were generally restricted to 55 and 73 m stations within the outer shelf group. *Brissopsis atlantica* and *C. chesheri* were restricted to Station M (except for one *B. atlantica* collected at Station C), as were *C. floridanus*, *A. excentrica*, and *E. laevigaster*. However, the latter three species were not included in the species cluster analysis since they were only represented by single specimens. Distinctness of Station M from its northern counterpart, Station E, is believed to be real and a result of being approximately 100 miles south in more tropical waters. Of the five rare species not included in the analysis of species associations, *C. floridanus*, *S. orbignyanus*, *A. excentrica* and *E. laevigaster* can be considered outer shelf species, and *A. magnifica* is either a middle or

outer shelf species. Sorting of echinoids into inner and outer shelf species within the Hourglass area compares well with the subjective separations discussed above, except for *E. t. tribuloides* and *M. v. ventricosa*. In both cases, these tropical inshore species are restricted to deeper water within the Hourglass area as a result of tropical submergence.

A similar cluster analysis was made for station associations based on echinoid distributions (Figure 46). It is statistically valid to include rarer species when clustering for station associations, and all 25

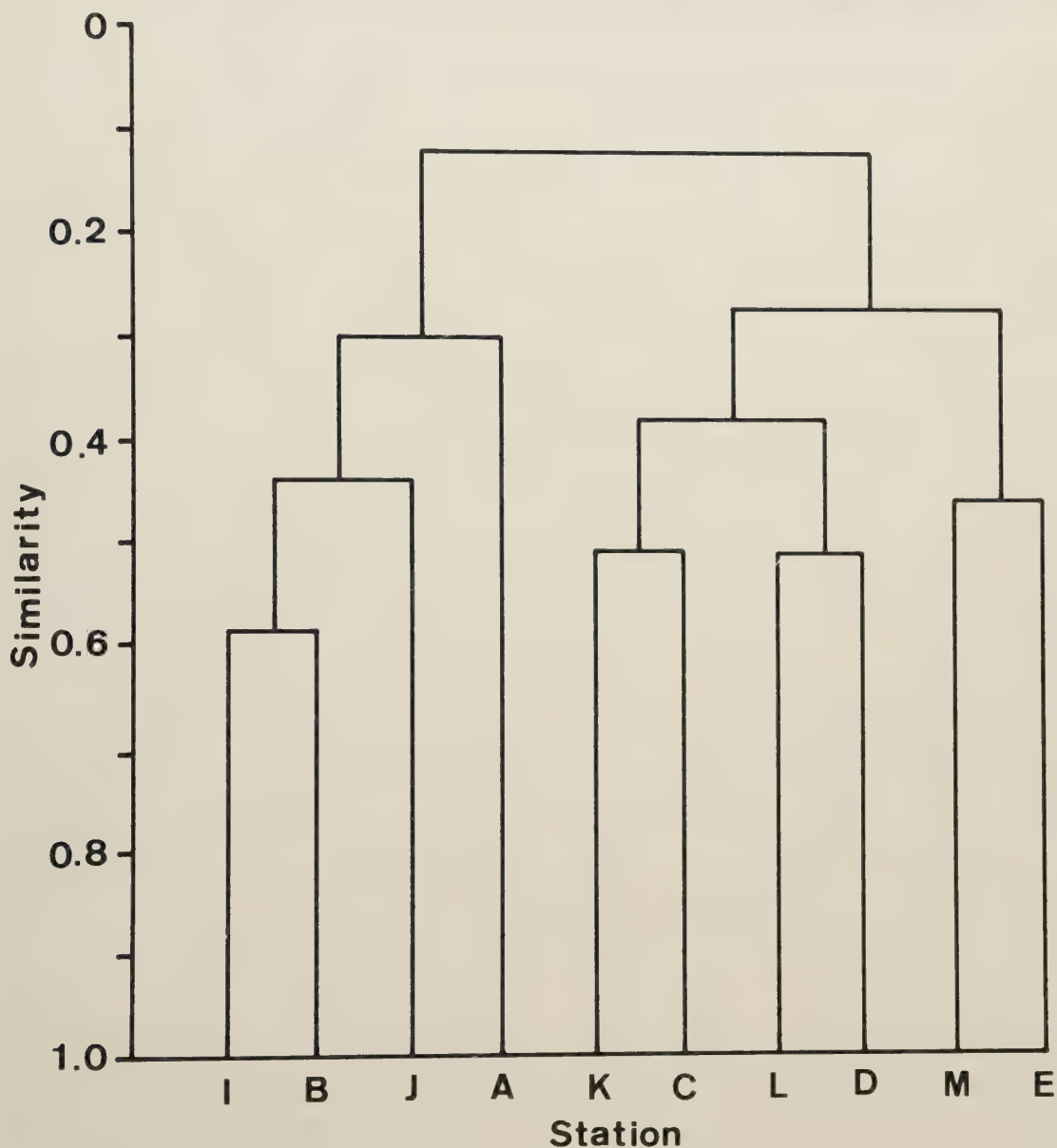


Figure 46. Similarities between Hourglass stations as indicated by distributions of associated echinoids.

Hourglass species were included in this analysis. Stations clustered into a group composed of Stations A, B, I and J and a group composed of Stations C, D, E, K, L and M. Within the first group, Stations B and I have the most similar echinoid faunas, with *A. punctulata*, *L. v. carolinus*, *M. quinquiesperforata* and *E. michelini* as conspicuous members. Station J is similar to Stations B and I, with *A. punctulata* and *L. v. carolinus* as important faunal components, but it differs by replacing the sand dollars *M. quinquiesperforata*

and *E. michelini* with *E. aberrans*. Station A is similar to Stations B, I and J by having *A. punctulata* and *L. v. carolinus* as major components, but differs by having an extremely large population of *M. quinquesperforata* and a small population of *M. atropos*.

Within the other station cluster, there are three groups of stations with similar faunas. The first group includes the 37 m Stations C and K. These have *A. punctulata* and *L. v. carolinus* as important members of the community, but these species are present in lower concentrations than at more inshore stations. Even though Stations C and K clustered into the second group, they appear to be more transitional between an inshore and an offshore fauna than would otherwise be expected from Figure 46. The inner shelf sand dollars *M. quinquesperforata* and *E. michelini* have been replaced at Stations C and K by the outer shelf species *C. prostratus*. The inner shelf *E. aberrans* and the outer shelf *S. affinis* occurred at Station K but were not taken at similar depths at Station C on the northern transect. *Meoma v. ventricosa*, which is generally an inner shelf species but occurred on the outer shelf within the Hourglass region, and the outer shelf *G. maculata* occurred in small numbers at Stations C and K but were more abundant further offshore. This mixture of inner shelf and outer shelf species at Stations C and K, and the fact that many other inner shelf species occurred there, indicates the transitional nature of these stations. Even though they clustered more closely to the deeper stations, they are considered part of the inner shelf group. The next group of stations includes the 55 m Stations D and L. The echinoid fauna at these stations was more closely related to the fauna at shallower Stations C and K than to the fauna at deeper Stations E and M. The dominant species at Stations D and L included the outer shelf species *G. maculata* and *M. v. ventricosa*, while the outer shelf species *C. prostratus*, *S. affinis*, *L. euerces* and *E. depressa* were present in lower numbers. The inner shelf species *A. punctulata*, *L. v. carolinus* and *E. t. tribuloides* occurred in low concentrations at Stations D and L. All specimens of *A. punctulata* from these stations were juveniles, with many juvenile dead tests present. The last group of stations included the 73 m Stations E and M, dominated by the outer shelf *S. affinis* and *G. maculata*, while the outer shelf *C. l. rubricingulus*, *L. euerces*, *C. ravenelii* and *E. depressa* occurred in lower concentrations. A few juveniles of the inner shelf *A. punctulata*, *L. v. carolinus* and *E. t. tribuloides* were present, but reproducing populations appeared to be absent. Station M appears to be somewhat distinct from its northern counterpart Station E, since *C. floridanus*, *A. excentrica*, *C. chesheri*, *E. laevigaster* and *B. atlantica* were all restricted to the former (except for one *B. atlantica* collected at Station C). However, all of these species were rare and only represented by one to five individuals collected during the 28-month sampling period. Station associations can be summarized as follows: Stations A, B, I and J are part of an inner shelf group containing inner shelf species; Stations C and K are considered part of the inner shelf group but are transitional with inner and outer shelf species present; and Stations D, E, L and M are part of an outer shelf group dominated by outer shelf species, but with a few individuals of inner shelf species present, generally from non-reproducing populations.

GULF OF MEXICO ECHINOIDS

The Gulf of Mexico is located at the extreme northern portion of a tropical western Atlantic fauna (Ekman, 1953; Briggs, 1974). Most taxa composing the shelf fauna of the Gulf have species which can be separated into three components, including a small endemic element, a warm-temperate element related to the fauna of the Atlantic coast of the United States, and a West Indian-Caribbean element (Topp and Hoff, 1972).

In order to determine whether this generality holds for echinoids, the continental shelves of the Gulf of Mexico and adjacent regions were divided into eight geographic areas for a more detailed description of known species distributions (Figure 47). These areas should not be considered zoogeographic regions, but were only established to show subtle faunal differences over a relatively small portion of the tropical western Atlantic fauna. Area 1 includes the shelf of the northern Bahamas and adjacent Caribbean Sea south of the Straits of Florida. Area 2 is the Florida Keys shelf extending from the Dry Tortugas in the West to near Miami in the east. Area 3 is the southeastern Gulf shelf and extends northward intertidally to near Cape

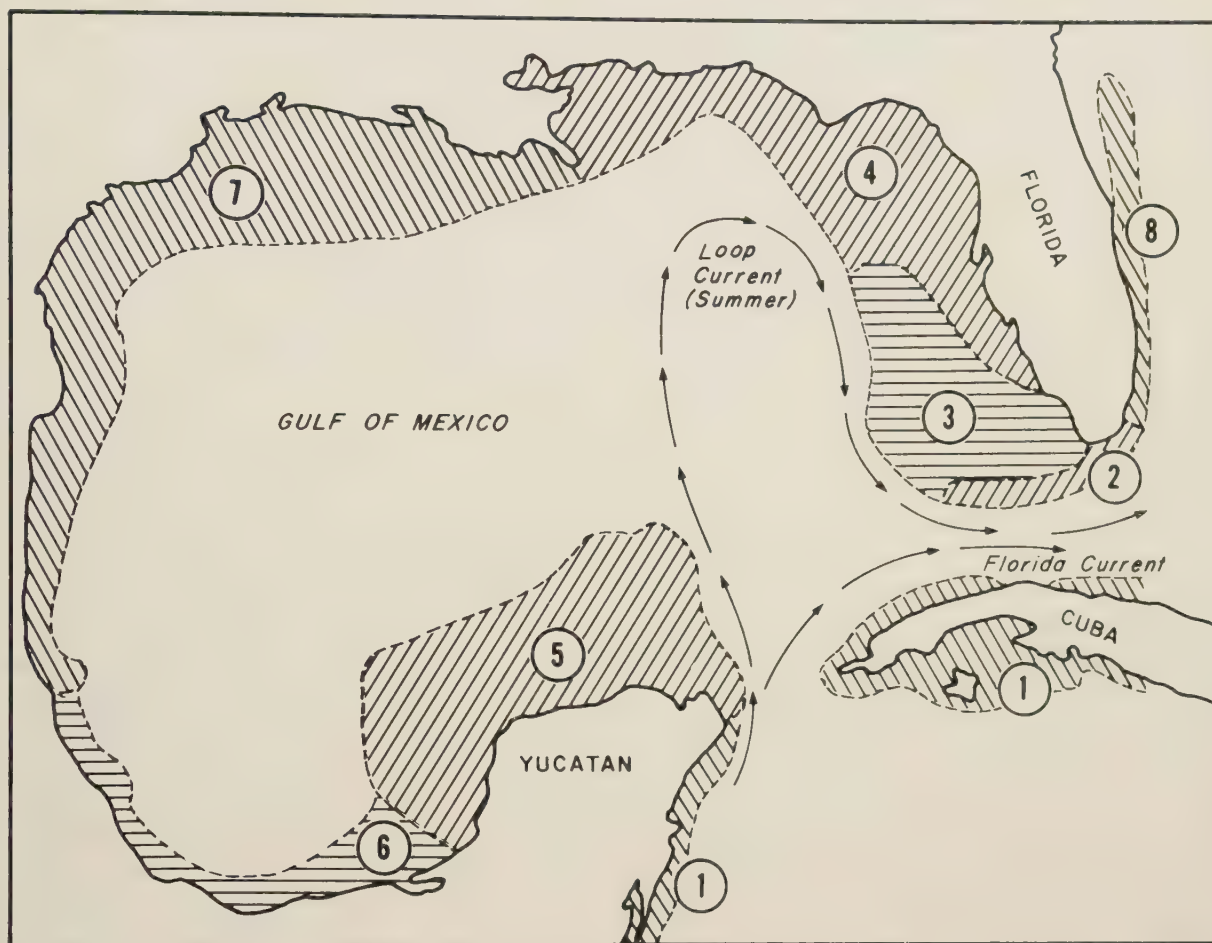


Figure 47. Gulf of Mexico and adjacent regions, showing eight geographical areas of differing echinoid faunal composition.

Romano, but offshore to west of St. Petersburg. These areas have been sampled rather extensively over the last century and the echinoid fauna is comparatively well known. Area 4 is the northeastern Gulf and extends from off the Mississippi Delta to St. Petersburg offshore and Cape Romano inshore. Historically, this area has not been sampled as extensively as the previous areas, but the echinoids are relatively well known. Area 5 occurs off the Yucatan Peninsula from off Sabuncuy, Campeche to off Cabo Catoche, Yucatan; sampling has been much less intense in this area, hence the echinoids are poorly known. Area 6 encompasses the southwestern Gulf of Mexico from off Cabo Rojo, Veracruz to off Sabuncuy, Campeche; it is about as poorly known as Area 5. Area 7 includes the northwestern Gulf from off the Mississippi Delta to off Cabo Rojo, Veracruz. It contains a few submerged reef systems such as the Flower Gardens described by Bright and Pequegnat (1974). According to Burke (1974), these reefs support isolated populations of tropical echinoids which are otherwise restricted to lower latitudes in the Gulf. These reef species are not known from the generally barren sand or muddy sediments more characteristic of Area 7. Area 8, off eastern Florida, extends from Miami to Cape Canaveral inshore, but occurs further north on the outer shelf to near the Florida-Georgia border. This area has been sampled extensively over the past century and probably has the best known echinoid fauna.

Table 30 shows known distributions of shelf, slope and deep-sea species within each of these eight areas. Shelf species are arranged in order from those which occur just outside the Gulf proper to those that occur throughout the Gulf. The general faunal elements discussed by Topp and Hoff (1972) for flatfishes of

TABLE 30. KNOWN DISTRIBUTIONS OF ECHINOIDS FROM THE
GULF OF MEXICO AND ADJACENT WATERS.

Species	1†	2	3	4	5	6	7	8
Species occurring on shelf or deeper								
<i>Lytechinus williamsi</i> **						I		
<i>Lytechinus callipeplus</i> **	O,S							O
<i>Clypeaster cyclopilus</i> **	O,S							
<i>Clypeaster lamprus</i>	O,S							
<i>Cassidulus caribaeorum</i> **	O							
<i>Echinocardium laevigaster</i>		O	O					O
<i>Cidaris abyssicola</i>	O,S	O,S						O,S
<i>Stylocidaris lineata</i>	O,S	O,S						O,S
<i>Tretocidaris bartletti</i>	I,O,S	I,O,S						
<i>Aspidodiadema jacobyi</i>	O,S	S						S
<i>Trigonocidaris albida</i>	O,S	S						S
<i>Echinus gracilis</i>	O,S	O,S						O,S
<i>Clypeaster euclastus</i>	O,S	S						
<i>Paraster n. sp.</i> **	I	I						
<i>Paraster doderleini</i> **		I						
<i>Paraster flordiensis</i> **	I	I						
<i>Brissopsis mediterranea</i>	O,S	O,S						
<i>Rhinobrissus micrasteroides</i> **	O,S	O,S						O,S
<i>Linopneustes longispinus</i>	O,S	O,S						S
<i>Paleopneustes tholoformis</i>	O,S	S						
<i>Araeosoma belli</i>	O,S	O,S,	O,S,					S
<i>Araeosoma fenestratum</i>	O,S	S	S					S
<i>Astropyga magnifica</i>	I	I	I					I
<i>Coelopleurus floridanus</i>	O,S	O,S	O					O
<i>Lytechinus euerces</i>	O,S	O,S	O,S					O,S
<i>Echinoneus clycostomus</i>	O,S	O,S	O,S					
<i>Clypeaster rosaceus</i>	I	I	I					I
<i>Leodia sexiesperforata</i>	I	I	I					I
<i>Paleopneustes cristatus</i>	O,S	O,S	O,S					O,S
<i>Salenia goesiana</i>	O,S	O,S	O,S	O,S				
<i>Clypeaster chesheri</i>	I,O	I	I	I				
<i>Schizaster orbignyanus</i>	I,O,S	O,S	O	I,O				O,S
<i>Plethotaenia spatangoides</i>	O,S	O,S	S	S				O,S
<i>Stylocidaris affinis</i>	O,S	O,S	O,S	O,S			O*	O,S
<i>Centrostephanus l. rubricingulus</i>	I,O,S	O	O	O			O*	
<i>Moiria atropos</i>	I,O,S	I	I	I			I	I
<i>Meoma ventricosa</i>	I,O	I,O	I,O	I,O			I,O*	
<i>Clypeaster prostratus</i>	I	I	I	I	I			I
<i>Clypeaster subdepressus</i>	I,O	I	I	I	I			I,O
<i>Echinolampas depressa</i>	I,O	I,O	I,O		I,O			I,O
<i>Conolampas sigsbei</i>	O,S	O,S	O		O			
<i>Agassizia excentrica</i>	O,S	O	O		O			O,S
<i>Tripneustes ventricosus</i>	I	I	I		I	I		I
<i>Echinometra viridis</i>	I	I	I		I	I		
<i>Brissus unicolor</i>	I,O	I,O	I,O		I,O	I,O		I,O
<i>Euclidaris t. tribuloides</i>	I,O	I,O	I,O	I,O	I,O	I,O	I,O	I,O,S
<i>Diadema antillarum</i>	I	I	I	I	I	I	I	
<i>Arbacia punctulata</i>	I,O	I	I	I	I	I	I	I
<i>Genocidaris maculata</i>	I,O,S	I,O	I,O	I,O	I,O	I,O	I,O	I,O
<i>Lytechinus variegatus</i>	I,O	I	I	I	I	I	I	I,O

TABLE 30. KNOWN DISTRIBUTIONS OF ECHINOIDS FROM THE
GULF OF MEXICO AND ADJACENT WATERS (Continued).

Species	1†	2	3	4	5	6	7	8
<i>Echinometra lucunter</i>	I	I	I	I	I	I	I	I
<i>Clypeaster ravenelii</i>	O	O	O	O	O	O	O	I,O
<i>Mellita quinquiesperforata</i>	I	I	I	I	I	I	I	I
<i>Encope aberrans</i>	I	I	I	I	I	I	I	I
<i>Encope michelini</i>		I	I	I	I	I	I	I
<i>Hypselaster limicolus</i>	I,O,S			O,S	O,S	O,S	O,S	
<i>Brissopsis alta</i>		O	O	O	O	O	O	O
<i>Brissopsis atlantica</i>	I,O,S	I,O	I,O	I,O	I,O	I,O	I,O	O,S
<i>Brissopsis elongata</i>	I,O			O	O	O	O	
<i>Plagiobrissus grandis</i>	I,O	I,O	I,O	I,O	I,O	I,O	I,O	I,O
Total Shelf Species	55	53	39	25	23	19	19	39
Slope and/or deep-sea species								
<i>Histocidaris sharreri**</i>	S							
<i>Habrocidaris scutata**</i>	S							
<i>Histocidaris nuttingi**</i>	S							S
<i>Poriocidaris purpurata**</i>	S							S
<i>Stereocidaris ingolfiana</i>	S							S
<i>Sperosoma antillense**</i>	S							S
<i>Plethotaenia angularis</i>	S							S
<i>Pourtalesia miranda</i>	S							S
<i>Neolampas rostellata**</i>		S						S
<i>Echinus tyloides</i>		S						S
<i>Sarsiaster griegi**</i>				S				S
<i>Hypselaster brachypetalous</i>				S			S	
<i>Cidaris blakei</i>	S	S						S
<i>Cidaris rugosa</i>	S	S						S
<i>Calocidaris micans**</i>	S	S						S
<i>Salenocidaris profundus</i>	S	S						S
<i>Salenocidaris varispina</i>	S	S						S
<i>Caenopedina cubensis</i>	S	S						S
<i>Echinocyamus macrostomus</i>	S	S						
<i>Araeolampas atlantica**</i>	D	D						D
<i>Podocidaris sculpta</i>	S	S	S					S
<i>Archaeopneustes hystrix</i>	S	S	S					S
<i>Homolampas fragilis</i>	S	S	S,D					S
<i>Palaeobrissus hilgardi</i>	S	S	S					S
<i>Hygrosoma petersi</i>	S	S	S	S				S
<i>Phormosoma placenta</i>	S	S	S	S				S
<i>Hemiaster expergitus</i>	S	S	S	S				S
<i>Echinocyamus grandiporus</i>	S	S	S	S	S	S		S
<i>Plesiadiadema antillarum</i>	S	S	S	S	S	S	S	S
<i>Aceste bellidifera</i>	S,D	S,D	D	D	D	D	D	D
Total slope and/or deep-sea species	26	20	10	8	3	3	3	25

* = Known only from Flower Gardens within Area 7

** = Rare species poorly known

I = Inner shelf 0-50 (75) m

O = Outer shelf 50 (75) - 200 (300) m

S = Slope 200 (300) - 2000 m

D = Deep-sea > 2000 m

†1 = Adjacent Caribbean and Bahamas

2 = Florida Keys

3 = Southeastern Gulf

4 = Northeastern Gulf

5 = Yucatan Peninsula

6 = Southwestern Gulf

7 = Northwestern Gulf

8 = Eastern Florida

the Gulf are displayed by the echinoids with only minor modifications. In the strict sense, there are no echinoids endemic to the Gulf proper, but *Brissopsis alta* is considered endemic since its only occurrence outside the Gulf is off the southeastern tip of Florida (southern portion of Area 8). There are only three shelf species which can be considered part of a warm-temperate component, and they inhabit the area referred to by Ekman (1953) as the Carolinean subprovince. These species include *Encope aberrans*, *E. michelini* and *Echinocardium laevigaster*, and they occur from Cape Hatteras, North Carolina south around the southern tip of Florida to Ft. Myers in the Gulf for *E. laevigaster* and throughout the Gulf for both *Encope* species. *Encope aberrans* has also been reported from the Bahama Islands, but only rarely. The shelf echinoids from the Gulf include a small eurythermal component containing wide-ranging species occurring from Cape Hatteras (occasionally Cape Cod) to Brazil. This component was not described by Topp and Hoff (1972) for flatfishes, but includes the echinoids *Arbacia punctulata*, *Mellita quinquesperforata* and *Schizaster orbignyanus*. The remaining 53 shelf species reported from the Gulf or adjacent waters are part of a large West Indian-Caribbean component. These echinoids range from those species which occur throughout the Gulf to species which have been collected from off Havana, Cuba, but not in the Gulf proper. An additional 20 species of slope or deep-sea echinoids are included in Table 30. Their distributions are more poorly known than previously discussed shelf species and are therefore not included in the discussion. The total number of shelf species listed for each area (Table 30) gives a relative indication of echinoid areal diversity. Areas from highest to lowest diversity are adjacent Caribbean and Bahamas (55 species), Florida Keys (53 species), southeastern Gulf and eastern Florida (both with 39 species), northeastern Gulf (25 species), Yucatan Peninsula (23 species), southwestern Gulf (19 species) and northwestern Gulf (19 species, but three species are known only from submerged reefs at Flower Gardens). As mentioned above, the echinoid fauna in Areas 5 and 6 off the Yucatan Peninsula and along the southwestern Gulf are poorly known, and those totals are expected to increase as more sampling is done.

From this, it is apparent that the Gulf of Mexico does not comprise a unique zoogeographic region for echinoids. With few exceptions, the fauna is composed of echinoids with West Indian or Caribbean origins which have invaded the Gulf of Mexico to varying degrees.

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